JANUARY 16, 1959

# electronics

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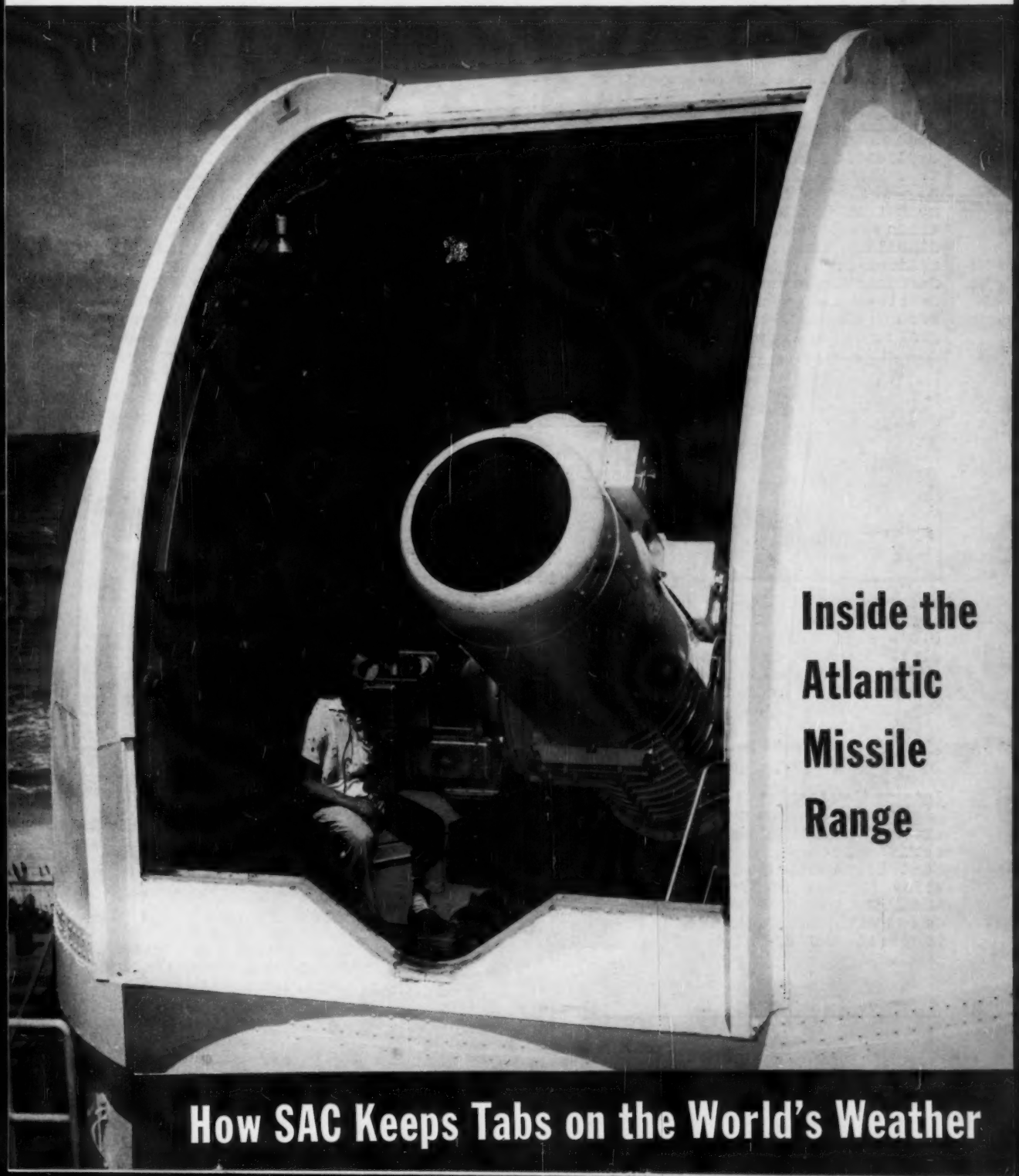


## Inside the Atlantic Missile Range

## How SAC Keeps Tabs on the World's Weather

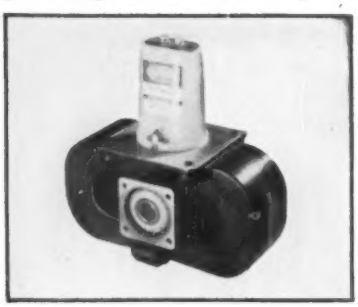
# Creative Microwave Technology

Vol. 1 No. 1

*Published by* MICROWAVE and POWER TUBE DIVISION
RAYTHEON MANUFACTURING COMPANY, WALTHAM 54, MASSACHUSETTS

## NEW DEVELOPMENTS IN ELECTRONIC TUBES AND CERAMICS

Where abnormal conditions of vibration (25 to 2000 cps at 10G) are encountered, such as in advanced airborne applications, this pulsed-type X-band (9245 ± 40 Mc) air-cooled RK6967A/QK366A magnetron oscillator maintains exceptional frequency stability and operational reliability. Optimum performance is assured by a double-end supported cathode and aluminum-clad integral magnets. Nominal peak



power output is 100 kw at typical pulse conditions of 0.5 μ sec. (.001 duty cycle). The tube operates at a peak anode voltage and current of 15 kv and 13.5 amp. respectively.

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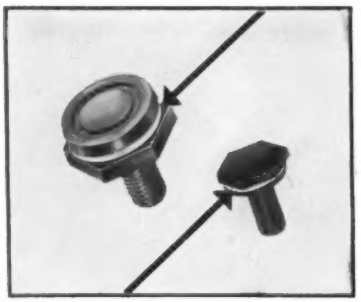
* * *

Integrally insulated semiconductors can now be produced by using high-alumina ceramic stem assemblies. Heat dissipating ceramic wafer (arrow) in the base insulates up to 2000 volts dc and withstands soldering temperatures as high as



1100C. Bases can be directly mounted to chasses or cold plates. Stems are available to all semi-conductor manufacturers.

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* * *

Miniature gyro feed-throughs provide take-off points from gas-filled gimbal housings. These high-alumina, vacuum-tight, R-95 ceramic assemblies can be soldered to housings at temperatures up to 1000C. They also assure positive electrical insulation with leakage less than one microampere per 500 volts dc.

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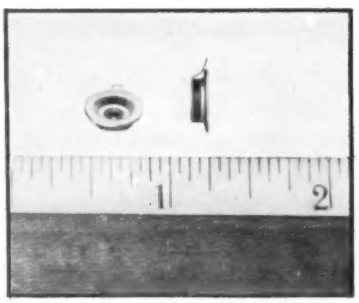


Designed for voltage tunable CW or pulsed operation over the Government X-band (8500 to 9600 Mc), the QK-684 integral magnet backward wave oscillator delivers 10 to 50 mW over delay-line voltages ranging from 215 to 325 vdc. Regulation of a special control grid facilitates pulsed or amplitude modulation to meet power and frequency requirements. Models available for coupling to standard, type "N" connectors.

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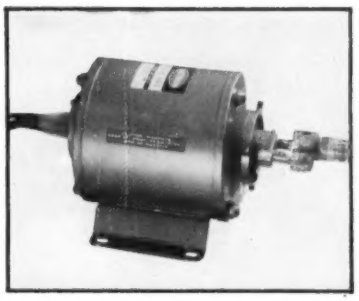

* * *

Compiled as a Raytheon service to the field, new Consolidated Data Booklet contains comprehensive information about principal unclassified magnetrons, klystrons, backward wave oscillators and special purpose tubes manufactured by Raytheon. Characteristics presented include maximum ratings, typical operating values, band or frequency ranges and other essential data for microwave engineers and purchasing departments.

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RAYTHEON

# electronics

JANUARY 16, 1959

A McGRAW-HILL PUBLICATION
Vol. 32 No. 3



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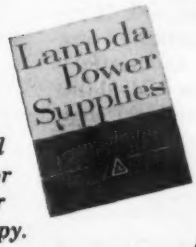


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Jan. 16, 1959 Vol. 32, No. 3

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# SHOPTALK

**UNDERGROUND WEATHERMEN.** Deep in their concrete and steel redoubt beneath the Nebraska plains, weathermen of the Air Force's Strategic Air Command keep an everwatching eye on weather conditions around the globe.

More often than not the eye is an electronic one. Radiosondes, weather radars, electronics-laden reconnaissance planes gather data. A wide-ranging radioteleprinter and facsimile network collects it while closed-circuit tv rounds out the picture.

On p 26, Associate Editor Mason brings you the whole story. including facts on this market for electronic gear.

**COMPONENTS AND MATERIALS**—Oldtimers in our industry may still remember when circuit design consisted of tieing together components selected from a limited assortment available to the engineer. The trick was to choose the proper circuit configuration and the correct component values.

Today, the component rather than the circuit is the limiting factor in electronic equipment design.

In his department, "Components and Materials", p 74, Associate Editor Jurgen keeps you up to date on new developments that can mean the difference between success and failure of your most recent design. Like most ELECTRONICS editors, Jurgen is an electrical engineer. He's an R.P.I. graduate. His professional life dates back to 1950, includes more than three years on our staff.

## Coming In Our January 23 Issue . . .

**ELECTRONIC ANGLER.** U.S. Fish and Wildlife Service fishery biologists needed a device to aid them in getting population data in streams and small rivers where nets, other collection aids can't be used.

Electronic Scientist H. P. Dale, attached to the Service in Seattle, has come up with an electronic device which fulfills the requirements. Pulsating d-c is passed through the water from a pair of electrodes. When fish enter the electric field surrounding the area, they tend to swim toward the positive electrode. As they get close, they are momentarily stunned and are easily captured with dip nets. Process is harmless to the fish.

**COLD TRANSISTOR.** While Associate Editor Weber toured the Bayside research laboratories of Sylvania Electric Products recently, he was fascinated by a new transistor that functioned normally while immersed in a bath of liquid nitrogen.

A few hundred questions later he had the groundwork laid for his article about this new solid-state development. The device exploits the properties of the boundary between two crystal lattice structures of different grain orientation in silicon or germanium. Sheet conductance at the boundary remains constant independent of temperature changes.

## An Editorial Future for You?

**THE NEW EDITORIAL FORMAT** we're now using substantially increases ELECTRONICS' engineering feature article content. Accordingly, openings now exist on the staff for engineering editors. If you have a degree in electrical engineering with a concentration in electronics, a year or so of experience in our industry, an insatiable curiosity about new circuits, components and systems and ability to write, edit and report technical developments, Editor MacDonald would like to talk with you about a future on the staff of this magazine.

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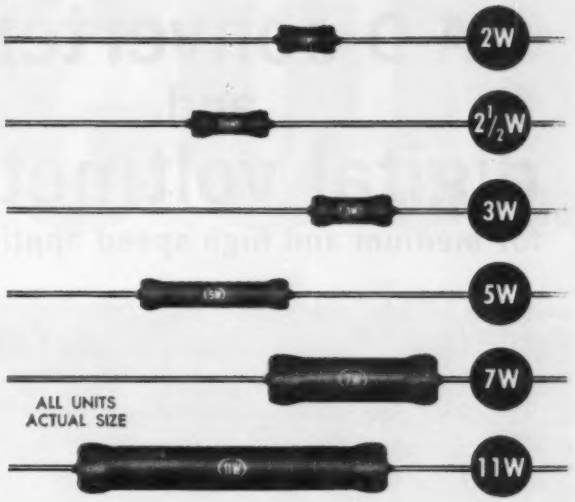


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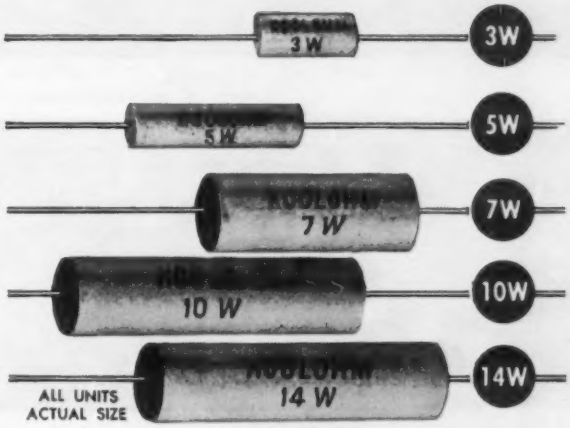


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**Merck Polycrystalline Rods**—are ready for zone melting as received . . . are ideal for users with floating-zone melting equipment. Merck Polycrystalline Rods (8½ to 10½ inches long and 18 to 20 mm. diameter—smaller diameters on special order) yield more usable material. In float-zone refining one can obtain minimum resistivities of 100 ohm cm. p type with minimum lifetime of 200 microseconds.

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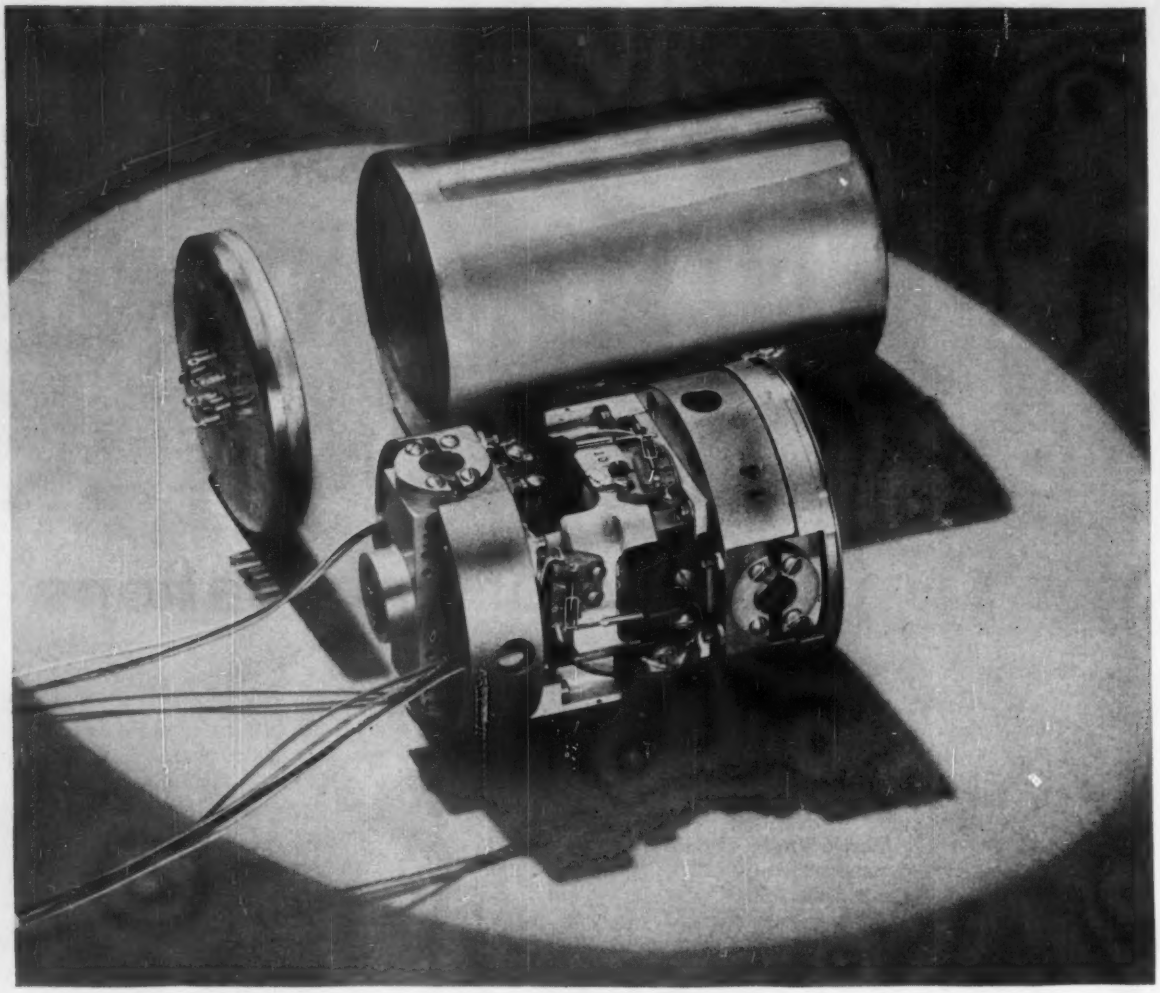

# New Humphrey dual-rate gyros do the work of two units

Now important reductions in the space required for instrument and control packages can be made with the introduction of a new Humphrey rate gyro that replaces two ordinary gyros. The new design utilizes a single motor to drive two separate wheels in one unit. With this new development, it is possible to measure rates about two different axes with an RG-18 Series Gyro or cover two different rate ranges about the same axis with a single RG-20 Series instrument.

RG-18 gyros should find widespread use for applications now requiring two instruments. For example, one unit could be used to measure both pitch and yaw. The RG-20 Series, with its two different rate ranges, may be applied to instrumentation systems where greater accuracy is required. For example, a single unit can be furnished to cover the rate ranges from 0—20 degrees/second and from 0—200 degrees/second. In effect, you expand the dynamic range of your instrumentation system from 100 to 1 to 500 to 1. This expanded scale gives you far greater accuracy.

The new rate gyros are built with two independent pick-offs—one for each axis or one for each range. They meet tough environmental conditions, such as temperature from −65°F to 180°F while operating, relative humidity 100%, unlimited altitude and excellent resistance to acceleration, vibration and shock. Phone or write today and let the kind of engineering that developed these new dual-rate gyros go to work for you.

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# How to save 77 years

The boy Galileo sat in the sanctuary of Pisa's great cathedral, observing the movement of a lamp which had been set swinging by a sudden gusty draft. The chain by which it was suspended from the high ceiling was of such a length that the arcs decreased but slowly. Strange thing, though. No matter how far the pendulum swung, its movement consumed the same time. Galileo made a note of that. The year was 1581.

The old man sat at his writing desk, sixty years and a thousand disputes later, writing down a new theory. The regularity of a swinging pendulum might be combined with a spring mechanism to improve the unreliable clocks of that day. So Galileo scribbled on, and did nothing more about it. A number of years after his death Huygens took the notes and invented the pendulum clock. *Seventy-seven years had elapsed since the boy made the observation upon which it was based!*

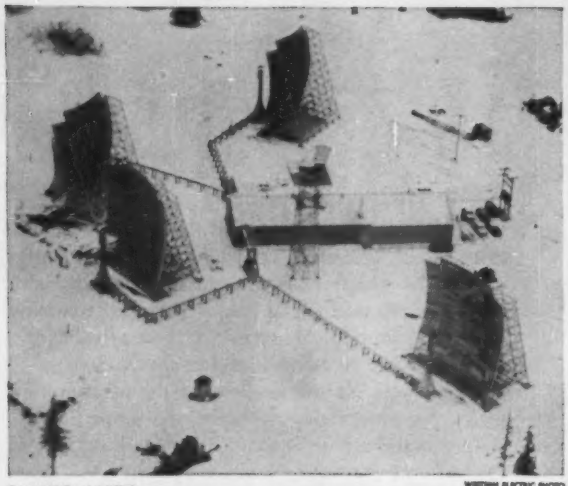
The creative thinker today still need not have a specific use in mind when, by equation or formula, he branches off from the accepted to the hitherto unknown. The classic invention of this decade, the transistor, evolved in the Bell Telephone Laboratories as scientists sought a deeper understanding of semiconductors. On the other hand, another great invention, the feedback amplifier, came from the acutely creative mind of one Bell engineer faced with a specific problem.

Current Bell Laboratories activities—in such areas as data transmission, radar and submarine cable development—call for the coordinated efforts of all types of thinkers and all types of approaches. One type complements another.

Today, seventy-seven years would not have elapsed between the swinging lamp and the swinging clock pendulum—certainly not at Bell Labs, where ideas, though not rushed, are carefully advanced toward fruitful application in national defense, industry and communications. An important part of this harvest is the efficiency of America's telephone service, unequalled anywhere else in the world.

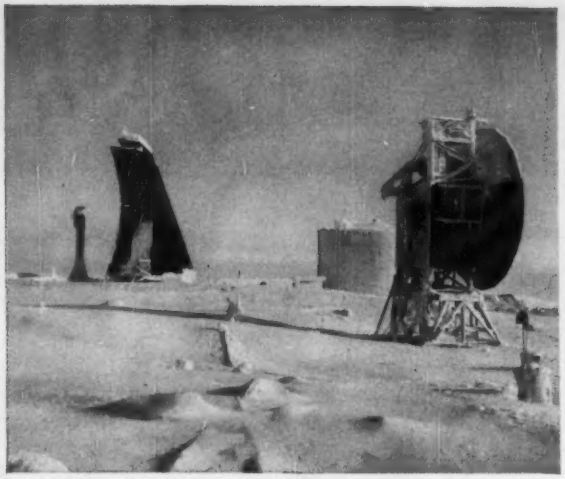
**BELL TELEPHONE LABORATORIES**

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

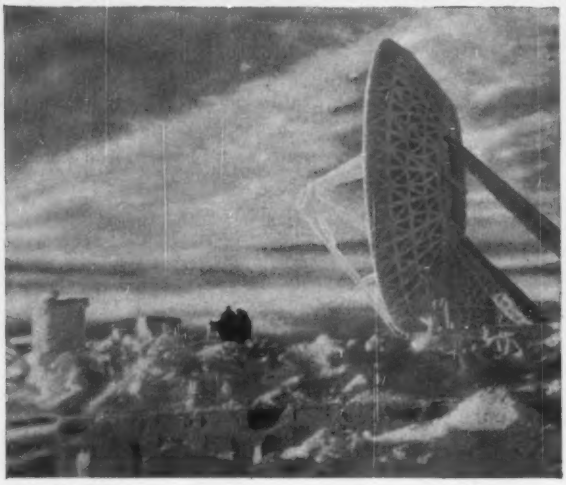


WHITE ALICE

WESTERN ELECTRIC PHOTO



DEW LINE



POLE VAULT

OFFICIAL U.S. AIR FORCE PHOTO

TEXAS TOWERS

## EIMAC KLYSTRONS performance proved in original Tropo-Scatter systems

Eimac klystrons are used in nearly every major military and commercial tropo-scatter system in the world. The list is impressive: Pole Vault, Texas Towers, Dew Line, White Alice, SAGE, NATO, Florida-Cuba TV, and numerous commercial networks. They have been selected for systems from Norway to North Africa, from the Arctic Circle to the Andes, from the United States to the Far East.

In most of these systems Eimac klystrons are used exclusively. The reason is simple: Eimac-pioneered external-cavity klystrons make it possible to generate high power at ultra-high frequencies simply, reliably and at low cost. With the Eimac external-cavity system, tuning cavities, couplers and magnetic circuitry are all external to and separate from the tube. This permits exceptionally wide tuning range and simplifies equipment design. Cost is lowered because this external circuitry is a permanent part of the transmitter and is not repurchased when tubes are replaced.

The reliability of these high-performance devices is exceptional. Some of the original Eimac klystrons installed in Project Pole Vault—the first major tropo-scatter network ever established—are still going strong with more than 25,000 hours of air time logged to their credit.

Eimac manufactures a complete line of amplifier and pulse klystrons covering the most important areas of the UHF spectrum. Write our Application Engineering Department for specific information.

**EITEL-McCULLOUGH, INC.**
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*Eimac First with ceramic tubes that can take it*

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*Cable address*
**EIMAC**
*San Carlos*

# ELECTRONICS NEWSLETTER

**AIRBORNE EARLY-WARNING** data system for Navy's Bureau of Aeronautics is scheduled for early flight tests. System, developed by Litton Industries, is designed to cut drastically time of interception of airborne targets and to reduce chance of human error in threat evaluation. Self-contained data-processing unit performs threat evaluation and vectoring calculations almost instantaneously. Information is displayed automatically so crew can track target, direct interception and communicate with ship and shore.

**NEW CHECKOUT AND LAUNCHING SYSTEM** for Atlas is being installed at Vandenberg AFB near Los Angeles. RCA Defense Electronic Products developed the system under subcontract to Convair Astronautics. Several U.S. launching sites are expected eventually to be equipped with the new electronic system. Firm says it will help make Atlas ready for firing "virtually immediately after a warning of impending enemy attack."

**U.S.-EURATOM** 10-year power reactor R&D program will spend $100 million in its first five years, with funds for the second five years expected to be of the same order of magnitude. Improved instrumentation is one goal of R&D that will go on before and after the selection of reactor projects.

*Moscow report says Soviet scientists are designing programmed control system for multistand steel mills able to roll steel at a speed of 60 to 75 miles per hour.*

**INDUSTRIAL INSTRUMENTATION OUTLOOK** for 1959 is one of increased activity, although there are "no straws in the wind" to indicate that sales will match peak 1956-1957 levels. So says Henry F. Dever, vice president of Minneapolis-Honeywell Regulator Co. He sees continuing trend through industry toward more complete and centralized operational control, which means new concepts and techniques and new forms of instrumentation.

**NEW METHOD FOR COATING** electron-tube cathodes which bonds a skin-tight film onto the nickel alloy sleeve is being used by Sylvania. Firm says "Sarong" method improves tube uniformity and efficiency, and will be used first in tv tuners.

*Phototransistor serving as wide-range pyrometer for inspection of parts of operating electron tubes is used by Philips. Lowest measurable temperature, determined by signal-to-noise ratio, is 200 C.*

**SERGEANT** surface-to-surface missile enters developmental hardware stage with awarding of Army contracts totaling about $22 million to Sperry Utah Engineering Laboratory, Salt Lake City, division of Sperry Rand Corp.

**TEMPERATURE CONTROL SYSTEM** for Tacan aboard F-86F Sabrejet will determine the amount of cooling available in the air supplied to the Tacan compartment rather than sensing temperature alone. United Control Corp., Seattle, has received contract from North American Aviation believed in excess of $500,000 for systems for 1,100 planes. Multichannel transistorized controller and two cooling-effect detectors are said to prolong Tacan life by maintaining constant temperature and to conserve air used for cooling other systems.

**HELICOPTER SKYHOOK** for 8,000-ft vertical wire antenna is used by Air Force Cambridge Research Center and Lightning and Transients Research, Inc., in simulating vlf signals of lightning discharges. Energized by transmitter delivering 3,000,000-volt pulses, the 25 kc signals were easily detected 70 miles away, had estimated range of 700 miles.

*Soviets are reportedly developing long distance waveguides to link cities with hundreds of thousands of channels for telephone and broadcast use.*

**SIMULATED NUCLEAR POWER PLANT** will be installed next July by Elliott Brothers of London at the 300 mw Berkeley nuclear power station. Gear comprises main control desk, analog computer cabinet housing 70 drift-corrected d-c amplifiers and 10 servo multipliers, and two wall-mounting boiler panels. System simulates graphite-moderated, gas-cooled, natural uranium-filled reactor with steam-raising and power generator side of six boilers, multiple heat exchangers and blowers supplying two turbo-alternators on dual pressure cycle.

*Inventions and Contributions Board has been set up by National Aeronautics and Space Administration. Job: Recommend rewarding inventors or waiving U.S. title to inventions made during NASA contract work.*

**AIR FORCE** has asked Battelle Memorial Institute, Columbus, O., to develop a simple totalizing recorder-computer that could be installed in a jet engine to predict engine failure and malfunction. Study is sponsored by Wright Air Development Center, is being conducted at Lockbourne AFB.

**INTEGRATED ANTENNA SYSTEM** for all communications components aboard the 2,000-mph F-108 interceptor is being designed and built by Electronic Specialty Co., Los Angeles.

**PULSE RADAR CLINOMETER** measures height of clouds from about 220 to 2,000 ft with an accuracy of about 10 ft at Ruzyne Air Field in Prague, Czechoslovakia. Instrument is supplemented by remote control device and recorder.

***Whatever you need in silver you can find at the***

## *HANDY & HARMAN SILVER SUPERMARKET*

Special today—and every day—silver in every form and grade you can name. By the ounce, inch, foot, and every other measure known to man.

All are of the consistent quality that has made—and kept—Handy & Harman first in the manufacture and development of silver and silver alloys for industry.

At the right are some of the general forms of silver made by Handy & Harman (what you don't see, ask for):

- Fine Silver (wire, strip and foil)
- Silver Anodes and Grain for plating
- Silver Contact Alloys
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- Silver Flake and Paint
- Silver Brazing Alloys
- Silver Electronic Solders
- Silver Sintered Metals
- Solder-Flushed Silver Alloys
- Silver Chloride and Oxide
- Coin Silver (wire and strip)
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**VISIT OUR BOOK DEPARTMENT**

We have five Technical Bulletins giving engineering data on the properties and forms of Handy & Harman Silver Alloys. We would like you to have any or all of those that particularly interest you. Your request, by number, will receive prompt attention.

| | |
|---|---|
| Fine Silver . . . . . | Bulletin A-1 |
| Silver-Copper Alloys . . | Bulletin A-2 |
| Silver-Magnesium-Nickel | Bulletin A-3 |
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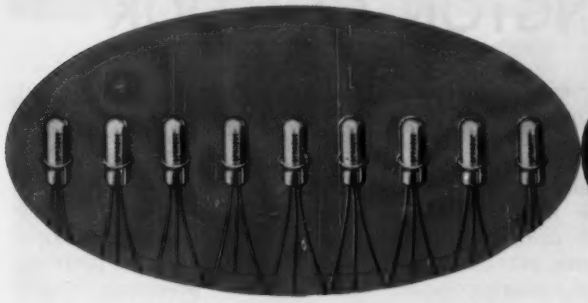
## new transistors from Sprague*



# SUPER HIGH-SPEED SWITCHING TRANSISTORS TYPE 2N501

| | Typical | Maximum | Units |
|---|---|---|---|
| Rise Time ($t_r$) | 9 | 18 | mμsec |
| Storage Time ($t_s$) | 9 | 12 | mμsec |
| Fall Time ($t_f$) | 7 | 10 | mμsec |

In circuit with current gain of 10 and voltage turnoff.

**Also available as special type 2N501A for 100° C. maximum storage and junction temperatures.**

This table tells the story. Sprague Type 2N501 germanium micro-alloy diffused-base transistors are the fastest mass-produced transistors available anywhere! They are unexcelled for high-speed computer applications. The ultra-low rise, storage, and fall time cannot be matched by any other transistor.

Ultra-precise process control in manufacture results in superb and consistent high quality. The basic electrochemical process of fabrication takes the guesswork out of transistor manufacturing. The result is outstanding uniformity of product.

Because of the electrochemical process, Sprague is able to fabricate a graded-base transistor with no intrinsic base region. The Type 2N501 can thus maintain its super high-speed switching characteristics right down to its saturation voltage, providing all the advantages of direct-coupled circuitry with no impairment of switching speeds.

Type 2N501 Transistors are available from Sprague now at extremely reasonable prices. They are transistors you can use today! You need not delay your development work for the future when you design high-speed switching circuits with Type 2N501 Micro-Alloy Diffused-Base Transistors.

Write for complete engineering data sheet to the Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

* *Sprague micro-alloy, micro-alloy diffused-base, and surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type numbers are manufactured to the same specifications and are fully interchangeable.*

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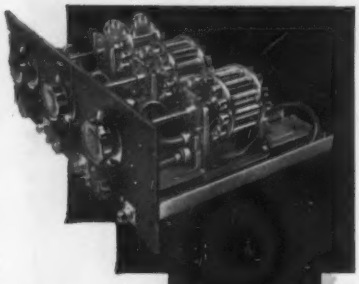
ATTENUATORS



DC to 1 KMC

ACCURACY (at DC)

1 to 5 db: .02 db
6 to 10 db: .05 db
20 to 50 db: .10 db

RF CALIBRATION ACCURACY

1 to 30 db: .1 db
40 to 50 db: .2 db

We supply individual calibrations at 400 and 1000 MC and, upon request, at other frequencies.

ATTENUATION RANGE

MODEL 60
2 drums, 0-60 db in 1 db steps

MODEL 64
3 drums, 0-64 db in .1 db steps

MODEL 640
3 drums, 0-110 db in 1 db steps

Impedance-50 ohms
Connectors-Female Type N

Long term repeatability and assured quality are a result of our experience in making coaxial attenuators with our own stable film resistors since 1947. Our facilities for attenuator calibration are the most accurate facilities available commercially.

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12 KMC.

Write for complete catalog, specifying frequency range of interest.

Weinschel Engineering

KENSINGTON, MARYLAND

CIRCLE 11 READERS SERVICE CARD

# WASHINGTON OUTLOOK

MISSILES AND ELECTRONICS contractors for Army Ordnance will be put through a wringer under a new Ordnance "value analysis" program aimed to cut procurement costs.

**An Ordnance team of engineers and auditors is inspecting contractor plants to seek new ways of reducing expenses. The inspectors check whether contractors can substitute less costly materials in performance of a contract; whether, in the transition to more advanced missile projects, the contractor can use surplus material left over from a preceding weapon project; and determine, in general, how to cut production costs.**

The program is patterned after a "value analysis" technique pioneered by General Electric's purchasing department a decade or so ago. In essence, program involves a study of material costs and their relation to the material's function. If it's decided the end product's function is not substantially improved by addition of a certain material, engineering changes will be made to eliminate what inspectors consider "luxury" costs.

Two missile plants have already been inspected by Ordnance's "value analysis" team. As a result, several engineering change orders have been issued on the projects involved. In one case the inspectors challenged the need for an extremely smooth finish on a missile part. They said the extreme finish specifications—and the added costs involved—"added nothing to the (part's) function." So the specs were changed.

- **An upheaval** in Pentagon research and development administration seems likely in the wake of Herbert York's appointment to the post of Director of Defense Research and Engineering. York, a prominent nuclear physicist and most recently chief scientist for the Pentagon's Advanced Research Projects Agency, fills the new post established by congress in the recent Defense Dept. Reorganization Law.

  **The new director has power to "supervise" all military R&D work and to "direct and control" projects which the Secy. of Defense determines need "centralized management."**

  The upheaval will come as York tries to cut through the maze of Pentagon bureaucracy surrounding military R&D projects. On paper, he has authority to pull the strings on each of the military services in all their R&D functions. Most details of York's operation have yet to be ironed out, however. The services will continue to fight efforts to take away their powers.

  **Presumably, though, York will have the power to allocate funds, to approve contractor selections, to initiate projects, and to assign them to individual services. And presumably this authority will run the gamut of military R&D—electronics, missiles and space work.**

  The position of William M. Holaday, the missiles czar who never really became a czar, is being abolished. His 38-man staff will be absorbed by York's new shop.

  **The position of ARPA, the Pentagon's year-old agency for directing military space projects, is very much up in the air. Theoretically, ARPA activities fall under York's new office. But ARPA Director Roy W. Johnson, a former GE vice president and York's former Pentagon boss, continues to report to Defense Secy. McElroy.**

  Most observers expect ARPA to wither on the vine. York's new office will wind up as the top-level office for running all military R&D, but actual administration of most projects will still be farmed out to the individual services and their contractors.

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CLEVITE GOLD BONDED DIODES FOR

# MECHANICAL RELIABILITY

**New manufacturing techniques increase ruggedness for rough service applications.**

Designed to withstand severe conditions of shock and vibration, the new Clevite ruggedized diode offers, in addition to the well known electrical advantages of gold-bonded diodes, a new high in mechanical strength.

For installation with automatic assembly equipment, for missiles, or other applications in which high values of acceleration are encountered, for all your diode needs, specify Clevite

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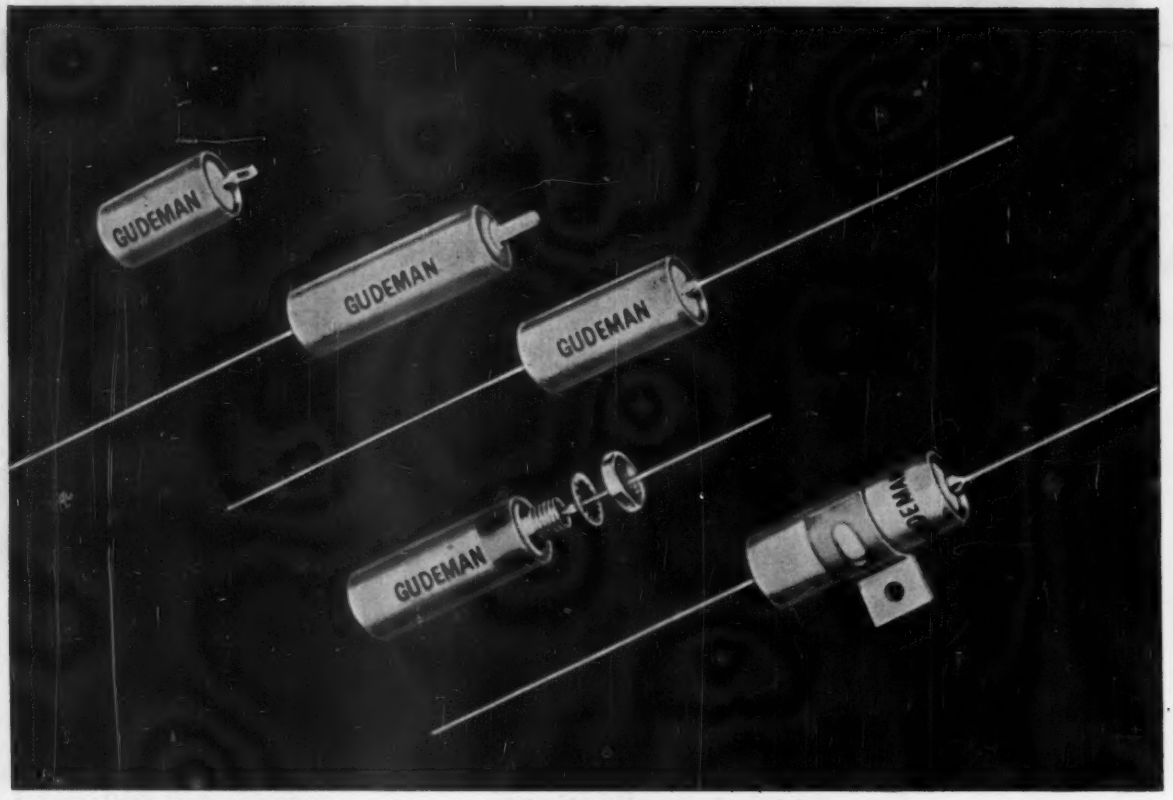
# Design better products with

# DOW CORNING 200 FLUIDS

## . . . ASSURE ADDED RELIABILITY AT EXTREME TEMPERATURES




These miniature capacitors made by Gudeman Company for filter, by-pass and blocking service, are impregnated with silicone fluids to decrease electrical losses and increase permissible operating temperatures. Designed to meet all specifications of characteristic "K" MIL-C-25A, they have an operating temperature range of —55 to 125 C.

TYPICAL DIELECTRIC PROPERTIES OF 200 FLUID, 100 CSTK.

| Property | Temperature —55 C | 23 C | 200 C |
|---|---|---|---|
| Dielectric Constant, | | | |
| 1.0 kcs. | 3.1 | 2.7 | 2.3 |
| 0.1 mcs. | 3.1 | 2.7 | 2.3 |
| Dissipation Factor, | | | |
| 1.0 kcs. | 0.0005 | 0.00004 | 0.001 |
| 0.1 mcs. | 0.0002 | 0.00001 | 0.0003 |
| Resistivity, ohm-cm. | $10 \times 10^{14}$ | $2.0 \times 10^{14}$ | $1.0 \times 10^{13}$ |
| Electric Strength, dc, 20 mil gap v/mil | 700 | 650 | 550 |

**As a liquid dielectric and coolant for electronic components and assemblies, Dow Corning 200 Fluid aids miniaturization and makes higher temperature operation possible. For example, paper capacitors impregnated with 200 Fluid have almost constant capacitance over an extremely wide temperature range . . . help assure reliable equipment performance. Heat stable electrical grade Dow Corning 200 Fluids show little change in electrical and physical properties over a wide range of frequencies and environmental conditions. Available in 20, 50, 100, 500 and 1000 centistokes viscosity grades, they are finding growing use as a means of increasing the reliability of capacitors, transformers, filter networks and other electronic devices.**

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**Dow Corning CORPORATION**
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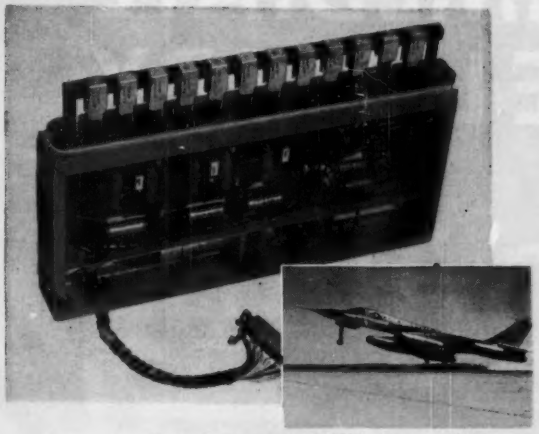
# Dow Corning Silicone Dielectrics



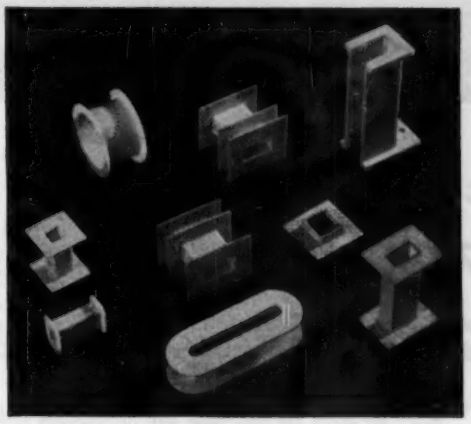
Electronic "Package" on B-58 by Emerson Electric.

## SILASTIC PROTECTS ELECTRONIC "PACKAGES"

**Silastic® the Dow Corning silicone rubber, remains resilient from —70 to 250 C, has excellent dielectric strength and offers superior resistance to moisture, ozone, corona and corrosive atmospheres. Available in many forms, including molded parts, extrusions, tapes, sheets and pastes, Silastic is ideal for insulating, sealing and cushioning delicate electrical and electronic equipment.**

CIRCLE 104 READERS SERVICE CARD

## SILICONE GLASS LAMINATES HAVE HIGH ARC RESISTANCE, STRENGTH



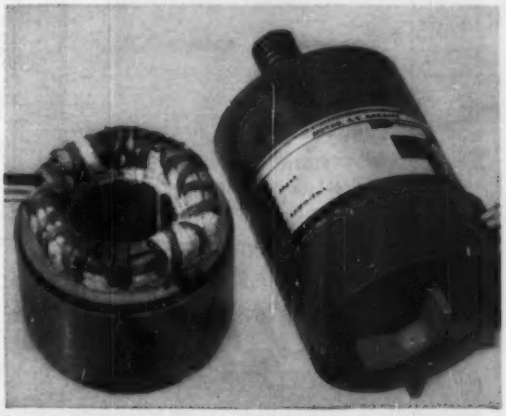
**Silicone-glass laminates are easily molded into one-piece core and flange structures. Strong even at flange joints, they are lightweight and moisture-resistant, retain excellent physical and dielectric properties at 250 C. Finished shapes are available from leading laminators.**

CIRCLE 105 READERS SERVICE CARD

## SILICONE VARNISH MAKES MOTORS TOUGHER, MORE DEPENDABLE

**Dipped or impregnated with Dow Corning 997 Varnish, the insulating components of motors, servos, generators, transformers and other assemblies are bonded into an integrated moisture resistant insulation system with high dielectric strength. This silicone varnish combined with other silicone components permits operating temperatures up to 250 C . . . protects against moisture, many chemicals and corrosive atmospheres.**

CIRCLE 106 READERS SERVICE CARD

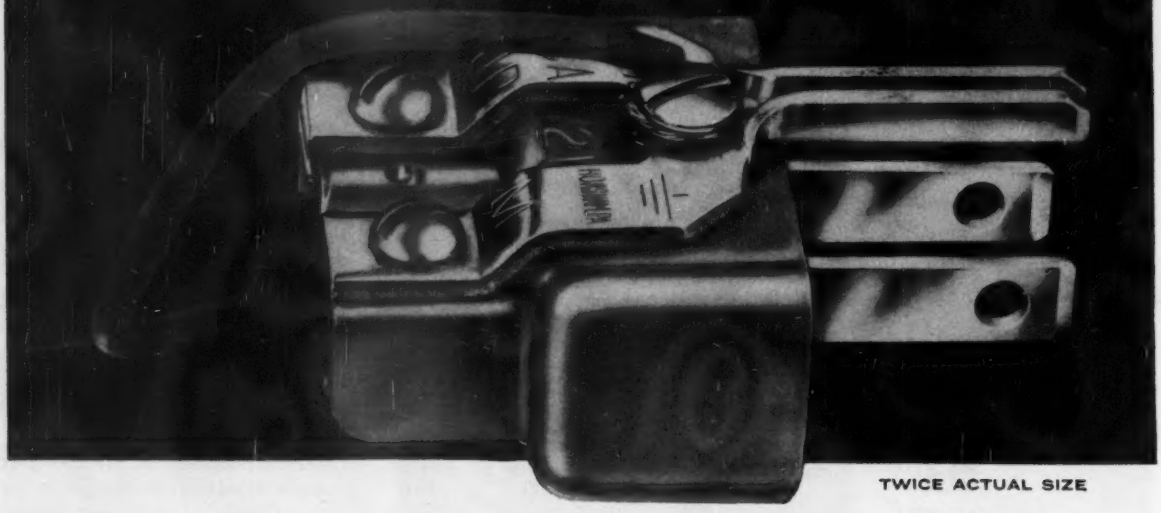


AiResearch miniature motors for B-52A Bomber.

For further information on these products, write Dept. 4813

Connector
*with*
Safety Grounding Blade

# IMMEDIATE DELIVERY



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## CONFORMS TO

## MIL-C-3767/4 Called out in

## MIL-T-21200 (ASG 1958) Suppl. 1 May 1958

**PRICE**

Be sure to get
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these connectors.
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The above new spec which calls for grounding blade for safety on electric connectors, need not cause you delay in approval of your equipment by the military. These connectors are available for either original equipment or changeover.

**COMPLETE CABLE ASSEMBLY AVAILABLE**

We can supply these connectors with or without the cabling of your choice (also strain relief bushings). Here are a few of the cables available. They conform to MIL-C-3432A.

CO-03 LOF(3/18)SJ0360 CO-03 MGF(3/18)0330
CO-03 AGF(3/18)0265 CO-03 HOF(3/16)0425

***BECAUSE WE BUY CABLE IN QUANTITY* YOU SAVE!**

**AVIONICS CORPORATION OF AMERICA**
HORSHAM, PA.

# More King-Size Mergers

KING-SIZE MERGERS in the electronics industry are increasing, as previously indicated (ELECTRONICS, p 6, Nov. 28, 1958).

Latest is proposed merger of **Texas Instruments** with **Metals & Controls Corp.** of Attleboro, Mass., recently approved by directors of two firms.

TI estimates 1958 sales of plus $90 million, while M&C expects $45 million. Former has 7,500 employees—latter, 3,000.

Texas firm, which has 3,256,988 common shares outstanding, is giving about 1/6 stock interest for the 922,647 M&C shares outstanding. M&C shareholders will be offered choice of 3/4s of a share of TI for each M&C share; or 8/10s of a share of TI convertible preferred and 4/10s of a share of common.

The exchange of shares would give TI a growth situation in the nucleonics field, facilities for manufacture of clad metals used for its semiconductors, and an industrial controls division.

Three major parts of the Attleboro operation are: **M&C Nuclear, Inc.**—a subsidiary; the **General Plate Division** and the **Spencer Division** (formerly **Spencer Thermostat Division**).

Growth of the nuclear subsidiary, which makes nuclear fuel cores, has been impressive. Number of employees rose from 190 to 664 in 1957 and recently topped 1,000.

• **Northrop Aircraft** readies for change in firm name to **Northrop Corporation.** Change is being made because of company's growth in new areas like guided missile electronic instruments and systems, target drones and space research. **Pacific Mercury Television** changes name to **Pacific Mercury Electronics.** Pacific Mercury, formerly a tv set specialist, now has a broad line of electronic products on the market.

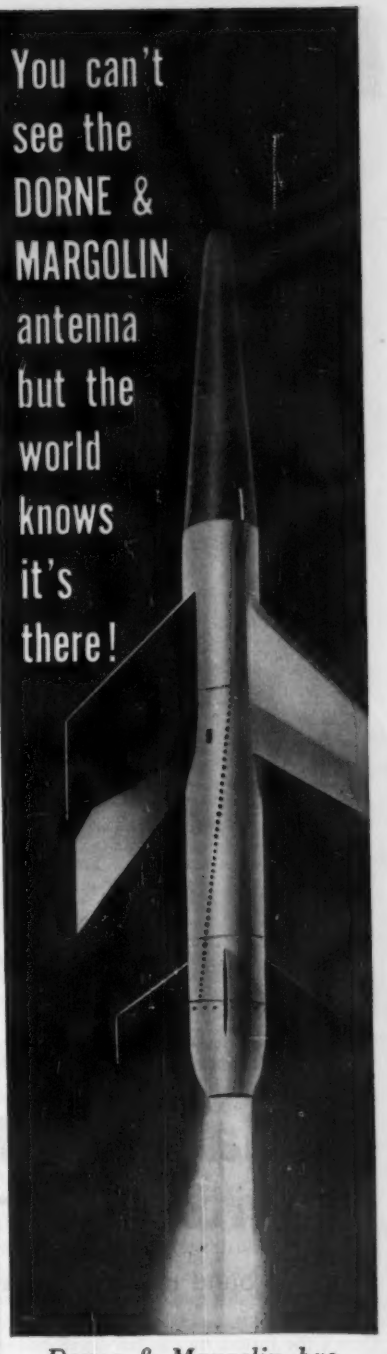
• **Dun & Bradstreet,** nationwide credit information firm, mails annual request for financial statements which will become part of D&B credit reports to nearly three million businesses. Credit firm points out business men can help establish or maintain their credit rating by returning statements promptly.

• **Stock issues** of small electronics firms are selling rapidly, underwriters report. Recent issues of **Ferro Dynamics** and **Narda Ultrasonics** stocks were quickly sold out.

## OVER THE COUNTER

| 1958 BIDS LOW | HIGH | COMMON STOCKS | WEEK ENDING Dec. 24 BID | Jan. 2 BID | ASKED |
|---|---|---|---|---|---|
| 3¾ | 20½ | Acoustica Assocs | 20½ | 23¼ | 25⅝ |
| 1⅝ | 3 | Advance Industries | 3 | 2⅞ | 3½ |
| 3⅛ | 6⅝ | Aerovox | 6¼ | 6⅛ | 7 |
| 20½ | 33 | Amer Res & Dev | 36 | 36 | 39⅞ |
| 16¾ | 24¼ | AMP Inc | 21½ | 21¼ | 25⅜ |
| 17⅝ | 69 | Ampex | 57½ | 61 | 67 |
| 5½ | 15 | Appl'd Sci Princet | 8 | 7⅝ | 10½ |
| 1⅛ | 8⅞ | Avien, A | 8⅞ | 8¾ | 9⅞ |
| 6¾ | 24 | Baird-Atomic | 22¼ | 22½ | 25⅛ |
| 9¾ | 13⅜ | Burndy | 13⅜ | 13⅜ | 14½ |
| 6¾ | 9 | Cohu Electronics | 6⅞ | 6½ | 7⅞ |
| 11 | 22½ | Collins Radio, A | 22½ | 22½ | 24⅝ |
| 10¼ | 22¼ | Collins Radio, B | 22¼ | 22½ | 24⅜ |
| 4 | 7 | Craig Systems | 6¾ | 6⅜ | 7¼ |
| 30 | 50½ | Dictaphone | 48 | 48 | 51⅞ |
| 17⅝ | 25⅜ | Eastern Industries | 21¼ | 21¼ | 23 |
| 22¾ | 29 | Eitel-McCullough | 29 | 28½ | 31⅛ |
| 10½ | 21 | Electro Instr | 23½ | 25 | 27¼ |
| 34 | 49 | Electronic Assocs | 49 | 50½ | 58½ |
| 5 | 11 | Electronic Res'rch | 11 | 11¼ | 14⅞ |
| 8½ | 12¾ | Electronic Spec Co | 12⅝ | 12¾ | 13⅞ |
| 15¼ | 49½ | Epsco, Inc | 41 | 41½ | 46⅛ |
| 5½ | 9⅜ | Erie Resistor | 8¾ | 8¾ | 9¾ |
| 10 | 17½ | Fischer & Porter | 15¼ | 15½ | 17 |
| 36¾ | 50 | Foxboro | 50 | 50 | 56½ |
| 5½ | 10½ | G-L Electronics | 10 | 10 | 11¼ |
| 12 | 27 | Giannini | 24¾ | 25 | 30⅜ |
| 30 | 39½ | Hewlett-Packard | 39½ | 39¼ | 42½ |
| 23¼ | 48 | High Voltage Eng | 47½ | 48 | 52½ |
| 1¾ | 3 | Hycon Mfg | 2¾ | 2⅞ | 3½ |
| 1⅛ | 5⅛ | Industro Trans'tor | 2¾ | 2⅞ | 3⅜ |
| 1½ | 4¾ | Jerrold | 3¾ | 3¾ | 4⅜ |
| 21 | 30 | D. S. Kennedy | 28¾ | 26¾ | 29⅞ |
| 3¾ | 29 | Lab For El'tronics | 29 | 26½ | 30⅞ |
| 19¼ | 28 | Leeds & Northrup | 28 | 27¾ | 30⅛ |
| 2 | 3⅛ | Leetronics | 1¾ | 1⅞ | 2⅜ |
| 5 | 18¾ | Ling Electronics | 17½ | 17⅜ | 18¾ |
| 16 | 22 | Machlett Labs | 20½ | 20½ | 22½ |
| 3¼ | 8¼ | Magnetic Amplifiers | 8¼ | 8¼ | 9⅛ |
| 2⅞ | 4½ | Magnetics, Inc | 3⅞ | 3¾ | 4¼ |
| 4⅝ | 12 | W. L. Maxson | 11 | 10⅝ | 12⅜ |
| 10⅝ | 29 | Microwave Assocs | 29 | 30½ | 33½ |
| 5¼ | 11¾ | Midwestern Instr | 11¾ | 11⅞ | 13⅛ |
| 1⅛ | 7 | Monogram Precis'n | 7 | 6¾ | 7⅞ |
| 3½ | 7¼ | Narda Microwave | 7⅛ | 7⅛ | 7⅞ |
| 9¾ | 16 | National Company | 16 | 15¾ | 17½ |
| 14¼ | 56 | Nuclear Chicago | 28 | 31½ | 34⅝ |
| 14½ | 29¾ | Orradio Industries | 29¾ | 27¾ | 31¾ |
| 4½ | 7⅜ | Pacific Mercury, A | 7 | 7⅜ | 8⅞ |
| 10⅛ | 27½ | Packard-Bell | 27½ | 27¾ | 30⅞ |
| 4¼ | 9⅜ | Panellit, Inc | 8¾ | 8¾ | 10 |
| 21 | 53¾ | Perkin-Elmer | 53¾ | 52 | 57½ |
| 11⅜ | 19½ | Radiation, A | 16 | 16⅛ | 18⅛ |
| 2⅛ | 7⅜ | Reeves Soundcraft | 6⅜ | 6½ | 7⅛ |
| 13 | 32½ | Sanders Associates | 28 | 28½ | 32½ |
| 7 | 12 | SoundScriber | 15¼ | 16 | 17¾ |
| 22¾ | 40 | Sprague Electric | 40 | 39½ | 43½ |
| 26 | 35 | Taylor Instruments | 35 | 34¾ | 38¼ |
| 5½ | 15 | Technical Operat'ns | 15 | 15½ | 18⅝ |
| 5½ | 15¾ | Telechrome Mfg | 15¾ | 15¼ | 17½ |
| 3¼ | 7¾ | Telecomputing | 7¾ | 7¾ | 8⅜ |
| 1⅛ | 2¾ | Tel-Instrument | 2¾ | 2¾ | 3½ |
| 8¾ | 16¼ | Topp Industries | 12¾ | 13⅛ | 14⅜ |
| 3¾ | 10¾ | Traceriab | 10¾ | 10½ | 12⅝ |
| 1⅛ | 3⅜ | Universal Trans'tor | 3¼ | 3⅜ | 3⅞ |
| 14¼ | 40 | Varian Associates | 40 | 39¼ | 45⅛ |
| 12½ | 18½ | Vitro Corp. Amer | 14¾ | 14½ | 16 |

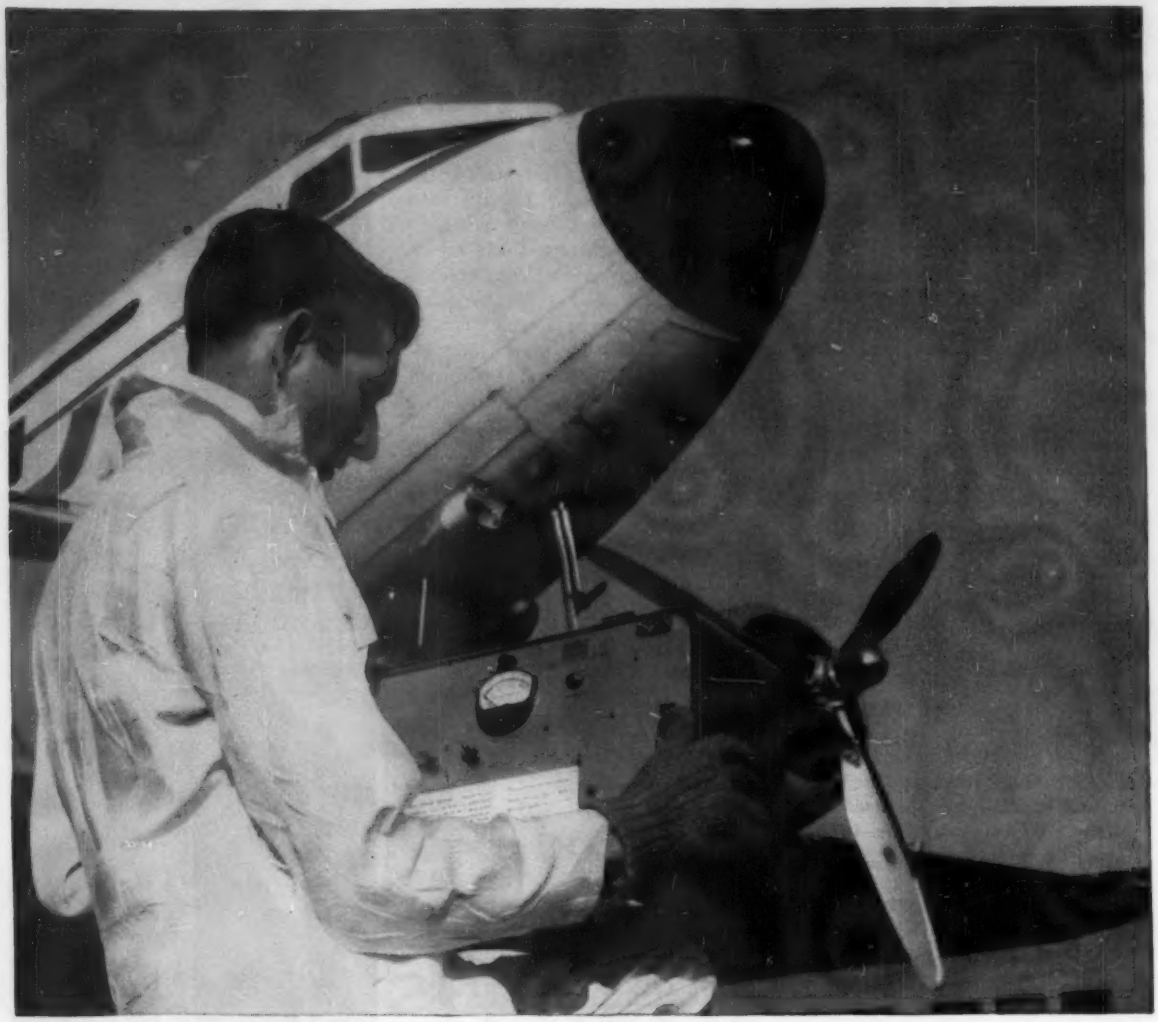
The above "bid" and "asked" prices prepared by the NATIONAL ASSOCIATION OF SECURITIES DEALERS, INC., do not represent actual transactions. They are a guide to the range within which these securities could have been sold (the "BID" price) or bought (the "ASKED" price) during preceding week.


*Dorne & Margolin has designed more antennas for more different missiles and aircraft than any other company in the nation.*

WRITE FOR CATALOG
**DORNE & MARGOLIN, INC.**
29 New York Ave., Westbury, N. Y.
West: 1434 Westwood Blvd.
Los Angeles 24, Cal.

CIRCLE 16 READERS SERVICE CARD



Panel light indicates when radar's ring time exceeds predetermined standard.
Other checks can be obtained with frequency indicator and relative power meter.

# Make flight-line checks of radars with Sperry's "go, no-go" tester

## C and X-band models available for immediate delivery

Here's the fastest means yet developed for testing aircraft radar on the flight-line or in the field. It's the new Sperry Microline® Radar Performance Tester and anyone can use it—no special training is required.

Weighing only 24 pounds (30 for C-band), this tester is self-powered (standard batteries) and is easily carried about. It prevents costly delays by providing a quick, over-all check of all aircraft radars in only minutes.

This is the only performance tester that checks the alignment between transmitter and receiver positively and accurately by flipping a single switch. Interchangeable plug-in echo box cavities permit checking either C or X-band radars. Transistorized circuits with built-in testing feature contribute to light weight and reliable performance.

If you'd like to know more about the new Sperry Microline Radar Performance Tester, write to our Microwave Electronics Company.

SPERRY

**SPERRY MICROWAVE ELECTRONICS COMPANY,** *CLEARWATER, FLORIDA • DIVISION OF SPERRY RAND CORPORATION*
***Address all inquiries** to Clearwater, Florida, or Sperry Gyroscope offices in New York • Cleveland • New Orleans • Los Angeles • San Francisco • Seattle*

# IF YOU NEED A BATH

VITREOUS ENAMEL IS FINE *

* Fixed wire wound resistors are generally coated with either a cement or a vitreous enamel. The vitreous enamels employed are similar—as one reference book appropriately remarks—to those used in kitchenware and bathrooms.

## But for Power Resistors you need IRC® Resisteg Coating

Consider the curing temperatures required for wire wound power resistor coatings and you'll readily see the advantages of IRC's exclusive RESISTEG Coating.

The low curing temperature of RESISTEG Coating is 205°F.—about the boiling point of water in many areas. Vitreous enamel must be cured at 1200°F., or higher!

IRC's low-temperature curing doesn't change the position of the wire, and winding turns do not shift together. No wire stretching, with its "work-hardening" aftereffect, is needed to prevent wire shifts.

RESULT: IRC Power Resistors have no "hot spots" from arcing-over. They offer greater stability, longer life and need no derating . . . even at high values.

Write for catalog of over 50 IRC Power Resistors including MIL types

—Wherever the Circuit Says—

IRC®

INTERNATIONAL RESISTANCE COMPANY
Dept. 332, 401 N. Broad Street, Philadelphia 8, Pa.

NEW
VIBRATING
CAPACITOR

A vibrating-reed type capacitance modulator for use in measuring currents as low as $10^{-16}$ amperes.

Long term stability for process control. Drift ±0.2 millivolts per day, non-cumulative.

Write for Catalog 523.

STEVENS
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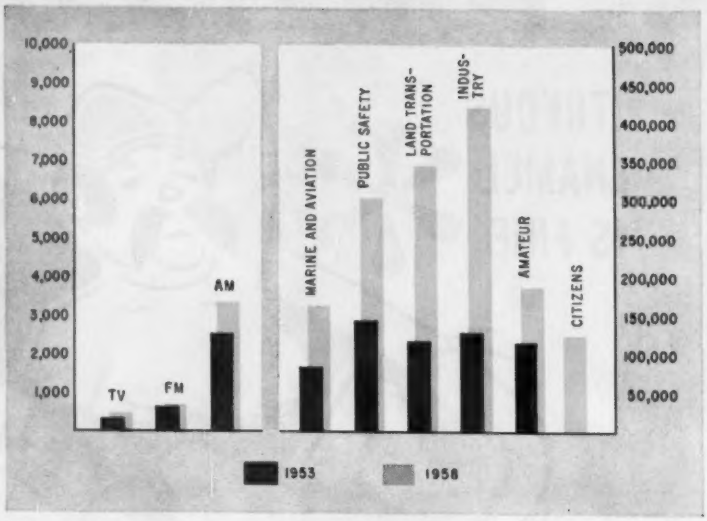
SOUTH BOSTON 27, MASS.

S/A-15

CIRCLE 19 READERS SERVICE CARD






# Transmitter Sales Rise Fast

SALES of transmitting equipment and associated receiving and control gear, especially mobile and portable rigs, are still climbing at a rapid rate. There are now over one and a half million transmitters operating in this country, with the number growing larger every month. Comparable figure for 1953 was 580,000 transmitters.

The chart above shows how aviation, marine, public safety and land transportation use of transmitting equipment has virtually doubled in the past five years. Increase by industrial users has almost tripled in that period. Citizens' radio has grown from zero in 1953 to about 125,000 in 1958.

Another newly-developing market is the one for tv translators. These are small (10 watts or so) uhf transmitters which rebroadcast from regular stations into areas not otherwise adequately covered. There are at present about 200 translators in use.

Today's one and a half million transmitting stations are spread among 65 different services, ranging from the 4,500 broadcast stations presently on the air with power up to 50,000 watts each, down to the 420,000 industrial stations operating with only a few watts emission apiece.

The second largest group of transmitters includes 342,000 used by railroads, buses, taxicabs, trucks and other mobile land vehicles. Another large category is the more than 300,000 used by public services, including police, fire, highway maintenance and forestry conservation departments.

Amateurs account for over 185,000 setups. Today these hams are buying more kits and fully assembled rigs than ever before. But they still include enough do-it-yourselfers to represent a sizable market for components.

Operating broadcast transmitters are 3,300 a-m, 720 f-m and 545 tv stations. Of the f-m stations on the air, 570 are commercial ventures. The number has been climbing steadily since 1957. The other 150 are low-power educational transmitters. There are 510 commercial and 35 educational tv stations on the air, with another 160 commercial ones authorized.

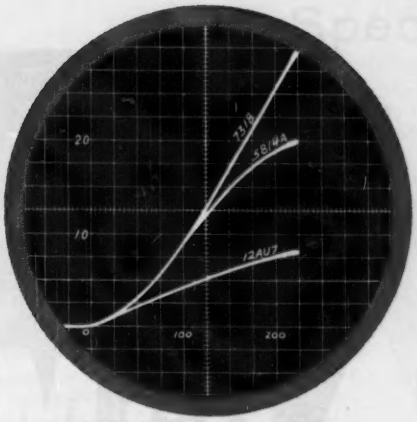
## FIGURES OF THE WEEK

### LATEST WEEKLY PRODUCTION FIGURES

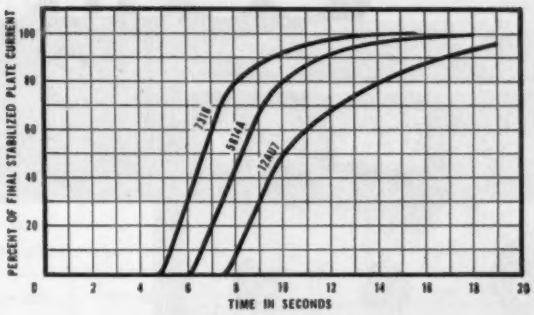
| (Source: EIA) | Dec. 26, 1958 | Nov. 28, 1958 | Change From One Year Ago |
|---|---|---|---|
| Television sets | 55,804 | 99,618 | —10.8% |
| Radio sets (ex. auto) | 206,932 | 338,887 | +38.2% |
| Auto sets | 88,112 | 109,098 | +58.2% |

### STOCK PRICE AVERAGES

| (Standard & Poor's) | Dec. 31, 1958 | Dec. 3, 1958 | Change From One Year Ago |
|---|---|---|---|
| Electronics mfrs. | 74.37 | 67.00 | +29.7% |
| Radio & tv mfrs. | 81.07 | 74.02 | +48.9% |
| Broadcasters | 79.88 | 77.13 | +35.2% |




"Y" Axis Peak Cathode Current in Amperes
"X" Axis Grid Drive in Volts




Warm-up characteristics of 7318 • 5814A • 12AU7

# New 7318 miniature pulse tube offers . . .

**. . . 2 AMPERES PEAK CURRENT**
The compact CBS-Hytron 7318 will provide, for example, 2 amperes peak current in 1.5-microsecond pulses at 2300 p.p.s.

**. . . FAST OPERATIONAL WARM-UP**
In less than 10 seconds the 7318 reaches 80% of steady-state plate current.

**. . . ENVIRONMENTAL TESTS EXCEEDING MIL-E-1**
Severe environmental tests and factory stabilization insure dependability of the 7318.

## COMPARE THESE ENVIRONMENTAL TESTS

| Test | CBS-Hytron 7318 | JAN 12AU7 JAN 5814A |
|---|---|---|
| High-frequency vibration | √ | None |
| High-frequency fatigue | √ | None |
| Low-frequency vibration | √ | √ |
| Linear acceleration | √ | None |
| Temperature cycling | √ | None |
| Shock (JAN 5-44) | √ | None |

CBS-Hytron 7318 exceeds MIL E-1 standard environmental requirements, most of them by factors of 3 or 4 times.

*More Reliable Products through Advanced-Engineering*

**CBS-HYTRON,** Danvers, Massachusetts
A Division of Columbia Broadcasting System, Inc.

**MANY USES** for this rugged 9-pin medium-mu twin triode include: industrial, computer, missile, satellite and manned-aircraft applications. The CBS-Hytron 7318 is ideal for blocking oscillators, square-wave modulators, multivibrators and hybrid tube-transistor circuits.

*Write for Bulletin E-318.* It gives complete technical and application data, characteristic curves and environmental ratings on the CBS-Hytron 7318.

# NOW!

**Constant output level**

**Constant modulation level**

**3 volt output into 50 ohms**

**Low envelope distortion**

# 50 kc to 65 MC

## NEW -*hp*- 606A HF Signal Generator

Here at last is a compact, convenient, moderately-priced signal generator providing constant output and constant modulation level plus high output from 50 kc to 65 MC. Tedious, error-producing resetting of output level and % modulation are eliminated.

Covering the high frequency spectrum, (which includes the 30 and 60 MC radar IF bands) the new -*hp*- 606A is exceptionally useful in driving bridges, antennas and filters, and measuring gain, selectivity and image rejection of receivers and IF circuits.

Output is constant within ±1 db over the full frequency range, and is adjustable from +20 dbm (3 volts rms) to —110 dbm (0.1 μv rms). No level adjustments are required during operation; the instrument has a minimum of controls and high accuracy results are assured due to the constant internal impedance. The generator can be provided with a 10:1 voltage divider and dummy antenna lowering minimum output to 0.01 μv (from 5 ohms) and simulating IRE standards for precision receiver measurements. (See Accessories Available in Specifications.)

The new -*hp*- 606A may be modulated by sine waves and complex waveforms from dc to 20 KC. A meter indicates percent modulation. Distortion in sine waves is extremely low due to use of a feedback circuit.

To insure maximum accuracy of frequency setting, the 606A includes an internal crystal calibrator providing check points at 100 kc and 1 MC intervals with error less than 0.01%.

**hp offers the world's most complete**

# Specifications

**Frequency Range:** 50 kc to 65 MC in 6 bands.

| | |
|---|---|
| 50— 170 kc | 1.76— 6.0 MC |
| 165— 560 kc | 5.8 —19.2 MC |
| 530—1800 kc | 19.0 —65.0 MC |

**Frequency Accuracy:** Within ±1%.

**Frequency Calibrator:** Crystal oscillator provides check points at 100 kc and 1 MC intervals accurate within 0.01% from 0° to 50° C.

**RF Output Level:** Continuously adjustable from 0.1 μv to 3 volts into a 50 ohm resistive load. Calibration is in volts and dbm (0 dbm is 1 milliwatt).

**Output Accuracy:** Within ±1 db into 50 ohm resistive load.

**Frequency Response:** Within ±1 db into 50 ohm resistive load over entire frequency range at any output level setting.

**Output Impedance:** 50 ohms, SWR less than 1.1:1 at 0.3 v and below. BNC Output connector mates with UG-88A/B/C/D.

**Spurious Harmonic Output:** Less than 3%.

**Leakage:** Negligible; permits sensitivity measurements down to 0.1 μv.

**Amplitude Modulation:** Continuously adjustable from 0 to 100%. Indicated by a panel meter. Modulation level is constant within ±½ db regardless of carrier frequency.

**Internal Modulation:** 0 to 100% sinusoidal modulation at 400 cps ±5% or 1000 cps ±5%.

**Modulation Bandwidth:** Dc to 20 kc maximum, depends on carrier frequency, $f_c$, and percent modulation as shown in the following table:

| | *30% Mod.* | *70% Mod.* | *Squarewave Mod.* |
|---|---|---|---|
| Max. Mod. Frequency | 0.06 $f_c$ | 0.02 $f_c$ | 0.003 $f_c$ (3 kc max) |

**External Modulation:** 0 to 100% sinusoidal modulation dc to 20 kc. 4.5 volts peak produces 100% modulation at modulating frequencies from dc to 20 kc. Input impedance is 600 ohms. May also be modulated by square waves and other complex signals.

**Envelope Distortion:** Less than 3% envelope distortion from 0 to 70% modulation at output levels of 1 volt or less.

**Modulation Meter Accuracy:** Within ±5% of full scale reading from 0 to 90%.

**Spurious FM:** 0.0025% or 100 cps, whichever is greater, at an output of 1 v or less and 30% AM modulation.

**Spurious AM:** Hum and noise sidebands are 70 db below carrier.

**Power:** 115/230 volts ±10%, 50 to 1000 cps, 135 watts.

**Accessories Available:** *-hp-* AC-606A-34 Output Voltage Divider with 50 and 5 ohms termination (10:1 voltage divider) and IRE standard dummy antenna (10:1 voltage divider). $50.00.

**Price:** (cabinet) $1,200.00. (rack mount) $1,185.00.

*Data subject to change without notice. Prices f.o.b. factory.*

# *Other -hp- Signal Generators—10 to 21,000 MC*

| Instrument | Frequency Range | Characteristics | Price |
|---|---|---|---|
| *-hp-* 608C | 10 to 480 MC | Output 0.1 μv to 1 v into 50 ohm load. AM, pulse, or CW modulation. Direct calibration | $1,000.00 |
| *-hp-* 608D | 10 to 420 MC | Output 0.1 μv to 0.5 v. Incidental FM 0.001% entire range | 1,100.00 |
| *-hp-* 612A | 450 to 1,230 MC | Output 0.1 μv to 0.5 v into 50 ohm load. AM, pulse, CW or square wave modulation. Direct calibration | 1,200.00 |
| *-hp-* 614A | 800 to 2,100 MC | Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calibration | 1,950.00 |
| *-hp-* 616A | 1,800 to 4,000 MC | Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calibration | 1,950.00 |
| *-hp-* 618B | 3,800 to 7,600 MC | Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, CW, FM or square wave modulation. Direct calibration | 2,250.00 |
| *-hp-* 620A | 7,000 to 11,000 MC | Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, FM or square wave modulation. Direct calibration | 2,250.00 |
| *-hp-* 623B | 5,925 to 7,725 MC | Output 70 μv to 0.223 v into 50 ohm load. FM or square wave modulation. Separate power meter and wave meter section. | 1,900.00 |
| *-hp-* 624C | 8,500 to 10,000 MC | Output 3.0 μv to 0.223 v into 50 ohm load. Pulse, FM or square wave modulation. Separate power meter and wave meter section | 2,265.00Δ |
| *-hp-* 626A | 10 to 15.5 KMC | Output 10 dbm to —90 dbm. Pulse, FM, or square wave modulation. Direct calibration | 3,250.00 |
| *-hp-* 628A | 15 to 21 KMC | Output 10 dbm to —90 dbm. Pulse, FM, or square wave modulation. Direct calibration | 3,250.00 |

ΔRack mounted instrument available for $15.00 less.

## -hp- 608D vhf Signal Generator

10 to 420 MC. Highest stability. No incidental FM or frequency drift. Calibrated output 0.1 μv to 0.5 v throughout range. Built-in crystal calibrator provides frequency check accurate within 0.01% each 1 and 5 MC. Master-oscillator, intermediate and output amplifier circuit design. Premium quality performance, direct calibration, ideal for aircraft communications equipment testing. $1,100.00.

***-hp-* 608C vhf Signal Generator.** High power (1 v max.) stable, accurate generator for lab or field use. 10 to 480 MC. Ideal for testing receivers, amplifiers, driving bridges, slotted lines, antennas, etc. $1,000.00.

## -hp- 626 A/628A shf Signal Generators

New instruments, bringing high power, wide range, convenience and accuracy to 10 to 21 KMC range. Frequencies, output voltage directly set and read. Output 10 to 20 db better than previous spot-frequency sets SWR better than 1.2 at 0 dbm and lower. Internal pulse, FM or square wave modulation; also external pulsing or FM'ing. *-hp-* 626A, 10 to 15.5 KMC, $3,250.00. *-hp-* 628A, 15 to 21 KMC, $3,250.00.

**HEWLETT-PACKARD COMPANY**

**4873A PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.**

**CABLE "HEWPACK" • DAVENPORT 5-4451**

***Field representatives in all principal areas***

# line of precision signal generators

Radiosondes (left) gather weather data at some 8,500 stations. Color tv camera in SAC's global weather central gives world-wide weather picture to rest of underground control center

# Forecasting World's Weather

**Global weather central handles 2,400 atmospheric reports an hour from more than 8,500 fixed locations and 1,000 ships at sea. All this means steady buying of electronic equipment**

SAFELY HIDDEN some three stories deep under Strategic Air Command headquarters near Omaha, Nebraska, military meteorologists of the Air Weather Service are working round the clock in the most elaborate weather forecasting complex in the world.

Measurements of atmospheric conditions from more than 8,500 fixed global locations and 1,000 ships at sea pour into the global weather central at the rate of 2,400 weather reports an hour.

Reports come in from:

- About 100 airbase weather stations supporting SAC; information is collected by radiosondes, radar weather reports, pilot weather reports and surface weather observations.
- Several unmanned weather stations located in inaccessible areas over the Northern Hemisphere; reports are radioed automatically at 60-minute intervals.
- Five weather reconnaissance squadrons of the Air Weather Service and several weather reconnaissance squadrons of SAC and TAC (Tactical Air Command) utilizing WB-50, RB-47 and RB-57 aircraft; reports are radioed back to home base 24 hours a day.
- About 8,000 civilian weather stations throughout the world, as well as thousands of military and commercial aircraft.

### *Hundreds of Charts*

Transmitted to SAC's global weather central by teleprinter via USAF's full period weather circuits, weather charts are made for different atmospheric levels from the surface to 70,000 ft. Thirty-six hour prognostic charts are prepared from which 2,250 separate temperature and height values are extracted and fed into SAC's IBM 704 computer.

In about 15 minutes, the computer, with its 32,000-word core and 8,000-word magnetic memory drum, produces five hemispheric charts showing forecast winds and pressures for all altitudes of operational interest to SAC. More specific information is provided for scheduled SAC missions, giving wind effects on aircraft, leg by leg, for each route flown.

By late 1961, global weather coverage will get a big and important boost. Designated weapons system 460L, a group of jet-powered weather stations, carrying the most advanced electronic weather reconnaissance system ever flown, will go into operation (ELECTRONICS, p 28, Sept. 19, 1958).

The weather reconnaissance system for the WS 460L, called the AN/AMQ-15, includes two radar systems, instrument-packed rockets, atmospheric sensing equipment and electronic computers. Precise telemetry, navigation and commu-

nications gear are also required for the aircraft.

### Valuable Data

At periodic intervals radiosondes will be launched from aircraft by rocket to probe the jet stream and other atmospheric phenomena at altitudes as high as 150,000 ft. Radiosondes will also be dropped by parachute to read weather data closer to earth.

An $11-million contract with the Systems Division of Bendix covers Phase I—the first 12 months of the estimated 36-month program—for R&D and flight testing of a breadboard weather system in Boeing's 707 jet airliner.

Work by other divisions of Bendix includes: Friez Instrument, rocketsondes and dropsondes; Radio, sonde radio receivers; Research Laboratories, instrumentation and sensor development; Bendix Pacific, cloud and storm radars; Eclipse-Pioneer, air data computers and storm radar antenna.

Boeing, besides providing the 707, is responsible for radomes and antennas, system installation, flight test, sonde dispensers, atmospheric electricity work, handling gear, parts of the air sampling subsystem, wind tunnel testing and aircraft integration.

### More Business

Other companies with subcontracts include: Cooper Development Corp., rockets and descent chutes; Filtron, interference suppression; University of New Mexico, ozone sensors; University of Texas, index of refraction measurement; Mast Development Co., ozone measurement; Thompson Ramo Wooldridge, airborne digital computer; Texas Instruments, cloud radar modulator transmitter; Epsco, multiplexers and converters; and Ampex, recording equipment.

Final system will use plug-in module design for easy maintenance and for a wider market. Portions of the system will be suitable for use in any transport plane.

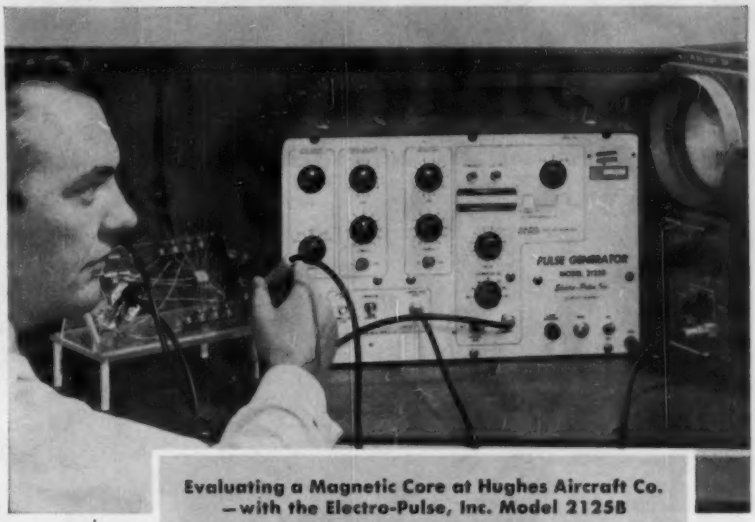
Invitations for contract bids for Phase II (fabrication of four flyable prototype systems) will be issued by Bendix Systems div., Ann Arbor, Mich., within the next three or four months.


Electro-Pulse, Inc.

**FAST PULSE GENERATOR**

**MODEL 2125B**

- 10 cps to 100 kc
- 0.1 to 100 μs pulse width
- 0 to 100 μs advance or delay
- 0.02 μs rise time
- 50 v into 50 ohms



**Evaluating a Magnetic Core at Hughes Aircraft Co. —with the Electro-Pulse, Inc. Model 2125B**

PHOTOGRAPH COURTESY HUGHES AIRCRAFT CO.

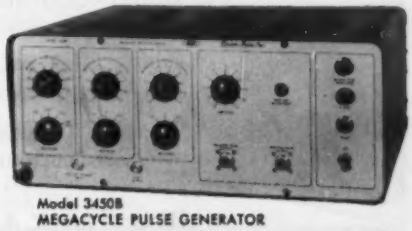
Only one of the many applications for the fast rise time high power output of the 2125B. These units are now in operation in laboratories across the U.S.A.

With optional delayed or advanced operation, and direct coupled output, the 2125B is ideal for delay line and pulse transformer tests, RADAR range simulation, and a wide variety of uses in pulse circuit study and design.

The 2125B is one of several general and special purpose pulse generators manufactured by Electro-Pulse. Others include Precision Pulse Generators, Pulse Code Generators, Variable Pulse Generators, Time Delay Generators, Pulse Oscillators, Voltage and Current Calibrators, and Electronic Counters.

**Write for Catalog 1958-59ED**

Representatives in Major Cities

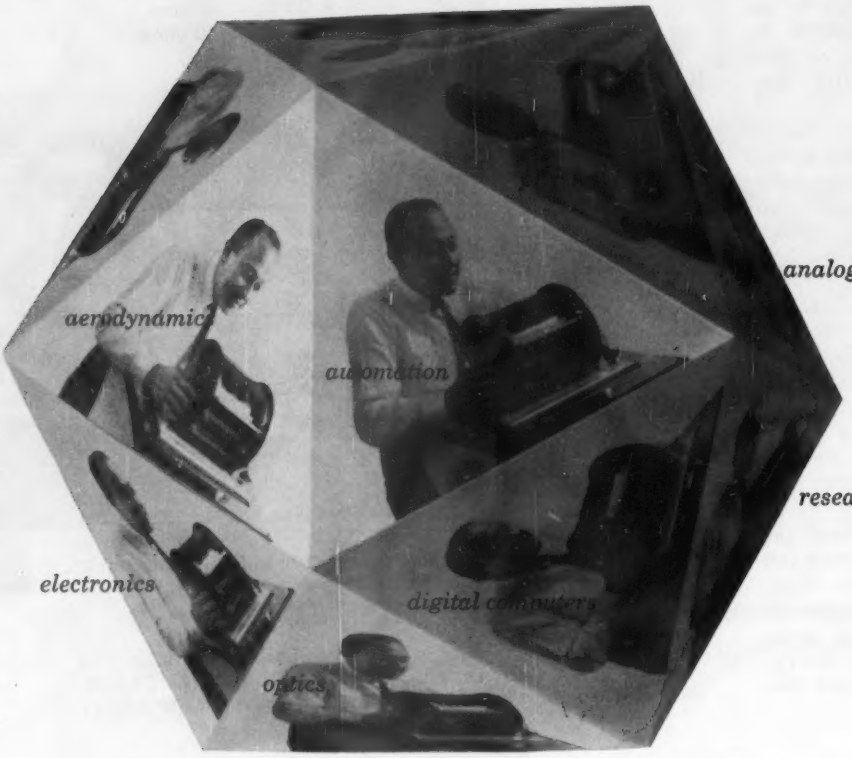


Model 3450B
MEGACYCLE PULSE GENERATOR

Electro-Pulse, Inc.

11861 TEALE ST., CULVER CITY, CALIF. • Phone: TExas 0-8006 or EXmont 8-6764

# ADD NEW DIMENSIONS TO YOUR CAREER...AT LINK-PALO ALTO




To the engineer pursuing a career, Link Aviation, Inc. offers a way of life... a new, wonderful, stimulating life in the charming suburban community of Palo Alto, California. Here, the *natural* climate rivals the *intellectual* climate for living at its finest. • Pioneers and world leaders in flight simulation, Link has become an important systems designer in many fields such as automatic control, optical and visual display, and radar simulation. • Academically, Link provides opportunity for study under regular university curriculum, with all tuition expenses underwritten, in the Stanford University Honors Cooperative Program. And Link offers all the employee benefits associated with advanced management practices. Excellent salaries. Generous hospital, health and retirement compensations. • There are immediate openings at all levels for engineers in analog and digital computers, radar simulators, automatic checkout equipment, complex electronic simulators, optical systems and electronic packaging.

*Write to Mr. K. A. Larko, Link Aviation, Inc., P. O. Box 1318 Palo Alto, California*

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**Accuracy:** .05% from .1 volt to 500 volts

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**Null ranges:** 10-1-.1-.01v

**Input Resistance:** Infinite at Null

**Resolution:** .005v at 500v to .00005v at .1v

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**Input voltage ranges:** 500-50-5v

**Null ranges:** 10-1-.1-.01v

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**Resolution:** .005v at 500v to .00005v at .1v

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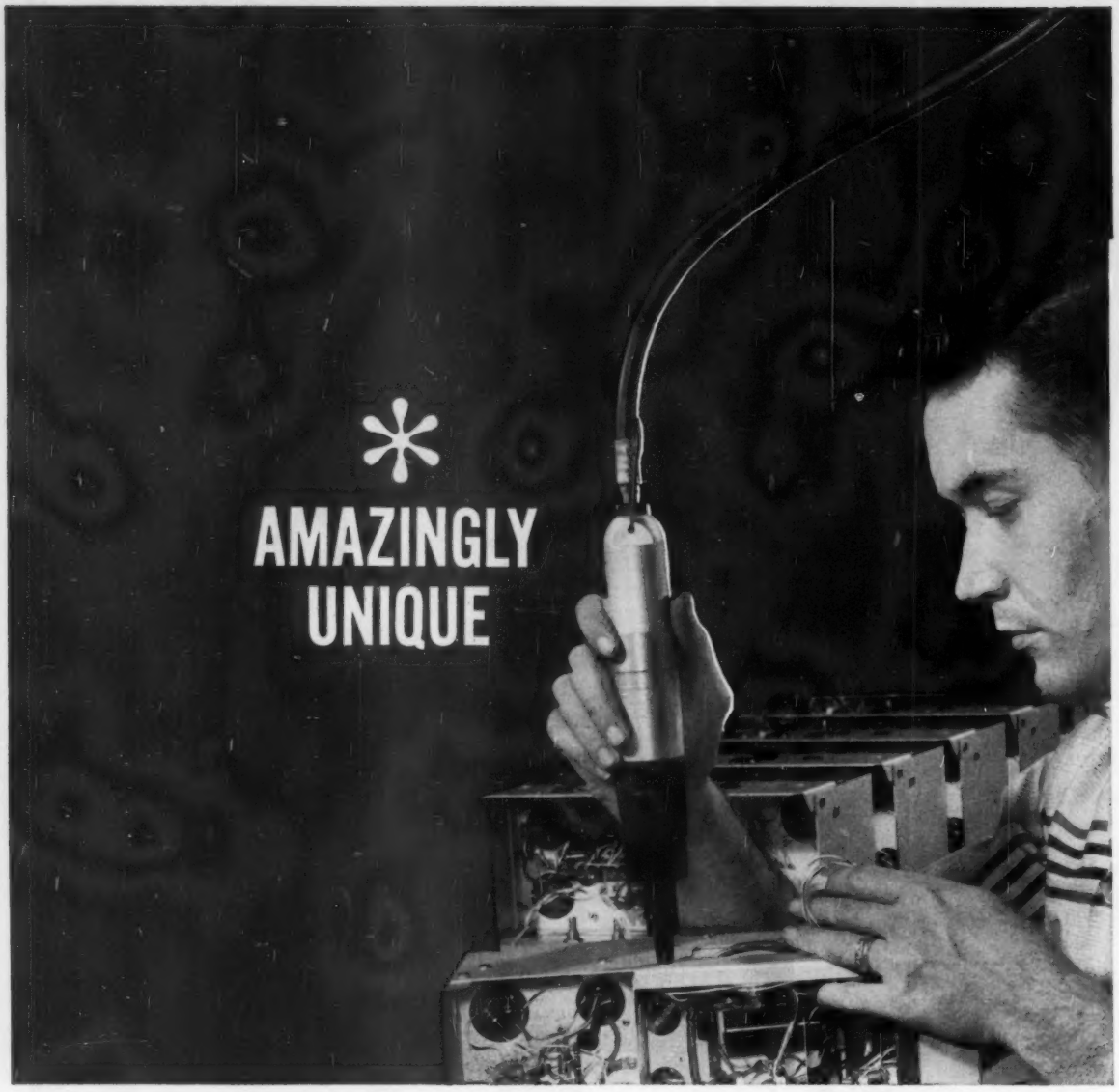


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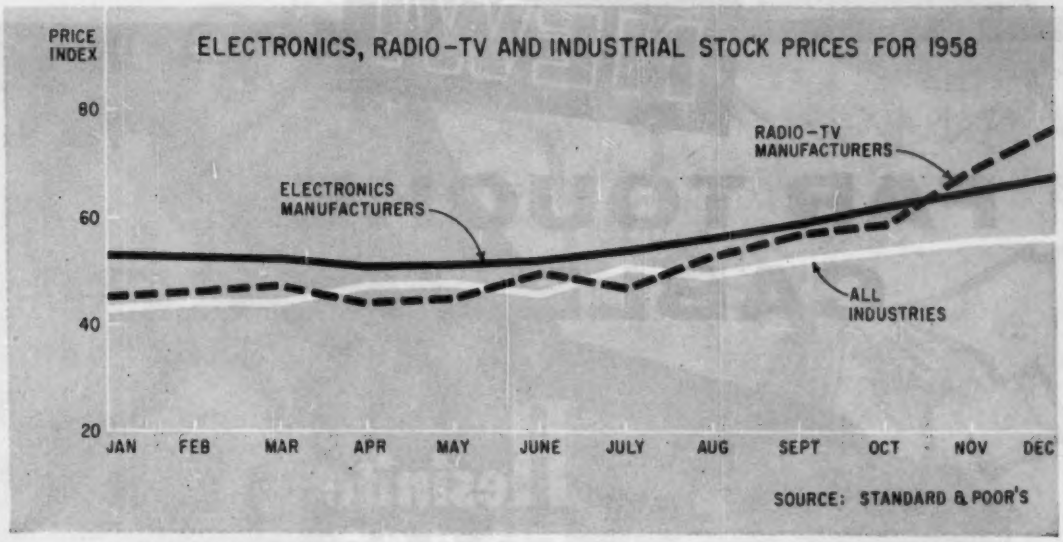


Electronics and radio-tv stock prices in 1958 went up . . . up . . . up

# Raising Money This Year

**Year 1959 should provide a golden opportunity for electronics firms to raise money. Most financial experts foresee relatively strong investor demand for electronics stocks**

YEAR COMING UP will be a golden opportunity for public financing by electronics firms.

Industry securities will sell at relatively high prices. Many firms in need of long-term capital will take advantage of the opportunity and issue securities. Investment banker interest in underwriting electronics issues is growing.

That's the consensus of opinion of leading investment bankers, venture capital groups, brokerage houses and investment trusts—all active in the electronics industry.

One financier says categorically: "Anyone who has plans to sell equity and doesn't issue securities in 1959 is crazy."

A more conservative minority opinion: "Sound electronics firms can make extremely good deals today. But the present healthy climate for electronics stock could change rapidly if Washington attitudes on defense spending shift."

Electronics stocks now appear to be entering the fad stage on Wall Street. This popularity rests partially on the growing feeling among investors that heavy military spending is here to stay.

It also rests on the standout price performance of electronics stocks last year. Many investors made big money with electronics investments in 1958.

The chart of Standard and Poor's stock-price indexes for 1958 shows that gains since April of electronics and radio-tv stocks far surpassed those of industry as a whole.

### *Standout Performers*

Too, gains of star performers in the electronics groups have been much more dramatic than the averages indicate. On the New York and American Stock Exchanges a number of electronics stock prices multiplied two to five times in 1958. On the over-the-counter market are instances of price gains five to seven times over the year's low.

But a strong note of caution underlies this rosy picture.

Some men fear a break in market price of electronics securities, point to many electronics stocks selling at prices 20 to 30 times current annual earnings—some cases 30 to 50 times.

Many observers are concerned about the military picture. Few look for major military spending cutbacks. But many fear elimination of some missiles and cutbacks in manned aircraft will hit some firms hard. Others point to pressure to prevent runaway spending and predict tightening up on military business profit margins.

The president of an electronics firm, which went public in a previous era of high prices, warns that public sale of stock at a high price may not be all profit.

"If prices drop you will have a lot of disgruntled stockholders on your neck. Also, a small firm will probably have to make several trips to the money market and investors who lost on the initial financing will not be eager for a second try."

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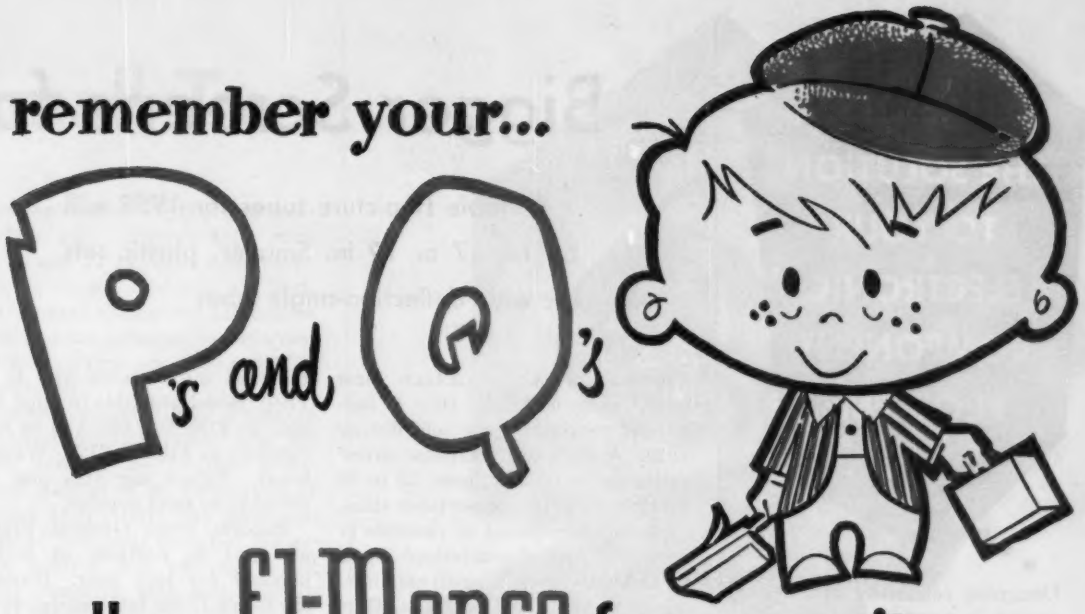


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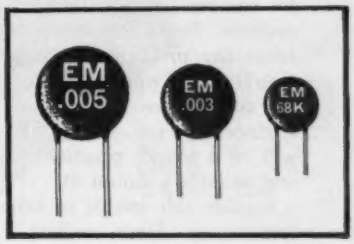

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# Bigger Screens for

## Portable tv picture tubes for 1959 will be 14, 17 or 19 in. Smaller, plastic sets use wide-deflection-angle tubes

FIGURES MADE AVAILABLE last month show that more than 4½ million tv receivers were sold during 1959. A review of manufacturers' estimates is that of these, 20 to 30 percent were in the portable class.

Early development of portable tv receivers was characterized by a scramble to produce small sets having 10 or 12-in. picture tubes. Current industry activity points to a leveling off now taking place with smallest popular picture tube sizes stopping at 14 in.

An observable trend resulting from this stabilizing is that manufacturers are concentrating on reducing chassis dimensions on popular sizes. For example, the smallest chassis in Philco's 17-in. portable series is now six inches deep compared to sixteen inches for 1957 models. In height, the Philco units are ten inches lower than the 1957 models. The sets make use of a picture tube having a flat, rather than a cylindrical, cathode. The Philco portables are priced between $180 and $190.

Referring to its smaller units as "carry-abouts" rather than "portables," Zenith is manufacturing 14 and 17-in. receivers. Both models use 90-degree picture tubes. The larger screen size has thus far attracted more buyers. The Zenith portables all contain power transformers identical to those used in the company's large console sets.

### *Wide-Angle Tubes*

Portable tv receivers figure importantly in RCA's 1959 line which features seven models; two 14-in., four 17-in. and one 21-in. Of these, the 21-in. model is said to be the most popular. The 14-in. model uses a 90-degree picture tube, the larger models use 110-degree tubes. All are transformer powered.

For 1959, Westinghouse has trimmed its portable line to one 17-in. model available in vinyl cabinets at $159 to $169, and in metal cabinets at $169 to $179. Westinghouse officials say this size was found to be most popular.

Reports from General Electric are that no portable as such is planned for this year. However, the firm's 17-in. table model weighs only 40 pounds.

Motorola reports better sales of 21-in. size sets than 14-in. sets. A company spokesman says his firm's sales emphasis will be on console and table models.

Market researchers at Emerson believe in the popularity of the 17-in. sets. Company plans to manufacture a 21-in. portable have been set aside.

**Design engineer shows modular chassis separation used in latest Sylvania portable**

Winter announcements from Sylvania reveal emphasis on 17-in. portables. Newly designed units weigh about 30 lbs., use 110-degree tubes and are powered by germanium rectifiers. The picture tube incorporates a new type of electron gun with fewer elements than older types. Weight reduction has been aided by the use of an all-plastic cabinet.

Two units in metal cabinets will

# Small Tv

be on the market for Olympic dealers this year. Picture tube sizes are 14 and 17 in. with predictions that the larger sets will sell best. The Olympic models use 110-degree tubes and are powered by selenium rectifiers. Prices are $150 and $170 respectively.

Remote control will be a feature of the Admiral portable sets for 1959. Admiral has stabilized portable set sizes at 17 in. Production of 10 and 14-in. units has been suspended. The units equipped for remote control will sell for about $219; standard sets will sell for about $200.

### Cordless Tv

Almost all major manufacturers are conducting research on a battery operated portable model. Summing up comments from manufacturers, the technical aspects of producing cordless sets can be met without too much difficulty. Basic roadblock as far as the mass market is concerned is price. The large number of specialized transistors that are called for by existing designs places set costs in a range of $350 to $500. Manufacturers feel certain that consumers will not pay this much for portable tv sets.

## Accelerator Scans Semiconductors

SMALL ELECTRON Van de Graaf accelerator at Bell Telephone Laboratories is exploring formation of defects in semiconductors and examining transients in semiconductor recombination process.

Use of electron machine capable of 1 mev at a d-c current of 25 microamps was reported by W. L. Brown at an accelerator conference in Cambridge, Mass., sponsored by High Voltage Engineering Corp.

Walton Van Winkle Jr. of Ethicon reported on electron beam sterilization of surgical sutures. He predicted use of irradiation to sterilize many pharmaceuticals.

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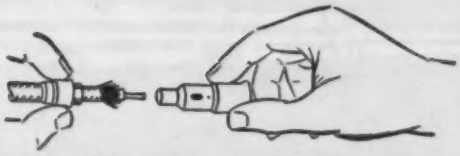

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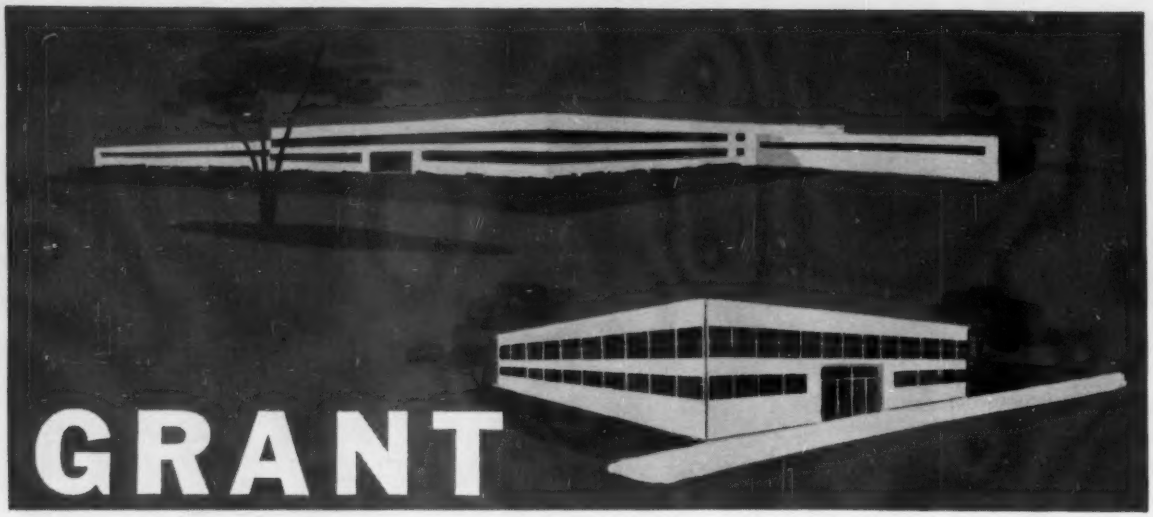


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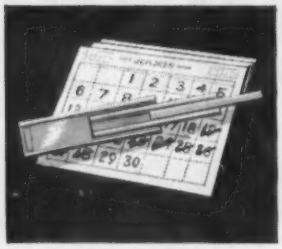

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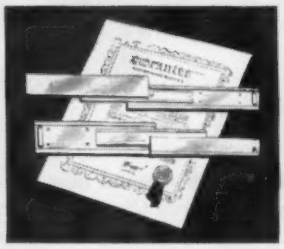

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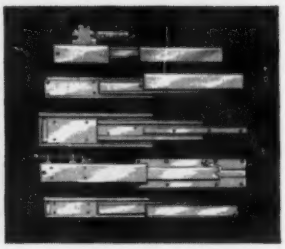

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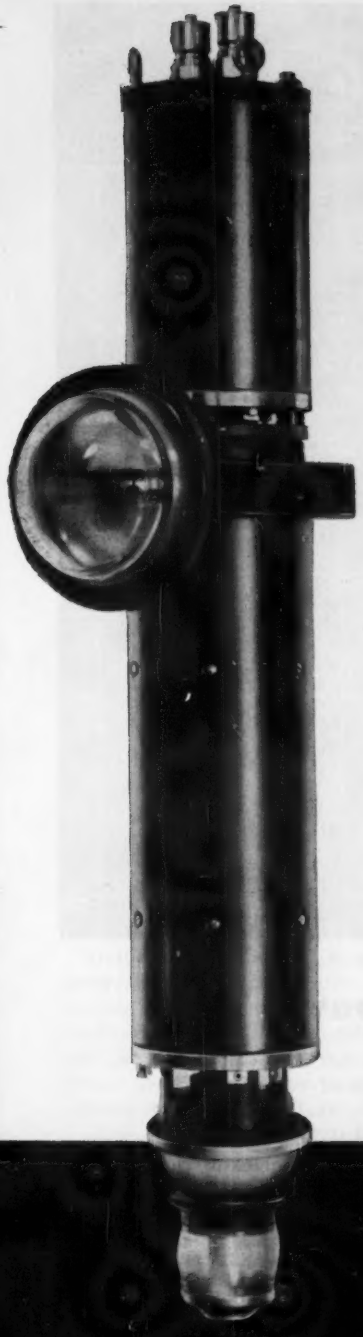

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The long life obtained in these tubes guarantees low cost per operating hour combined with low initial cost, thus placing linear accelerators within reach of many new users. New developments now approaching production include tubes with broad band operation, instead of tunable operation and modulating anodes. These developments will provide major improvements in systems where electronic tuning and shaped pulses are important.

The performance of our L-band klystron family has made Litton Industries the leading supplier of high powered klystrons in this range. Soon comparable families at other frequencies will enhance the reputation gained at L-band.

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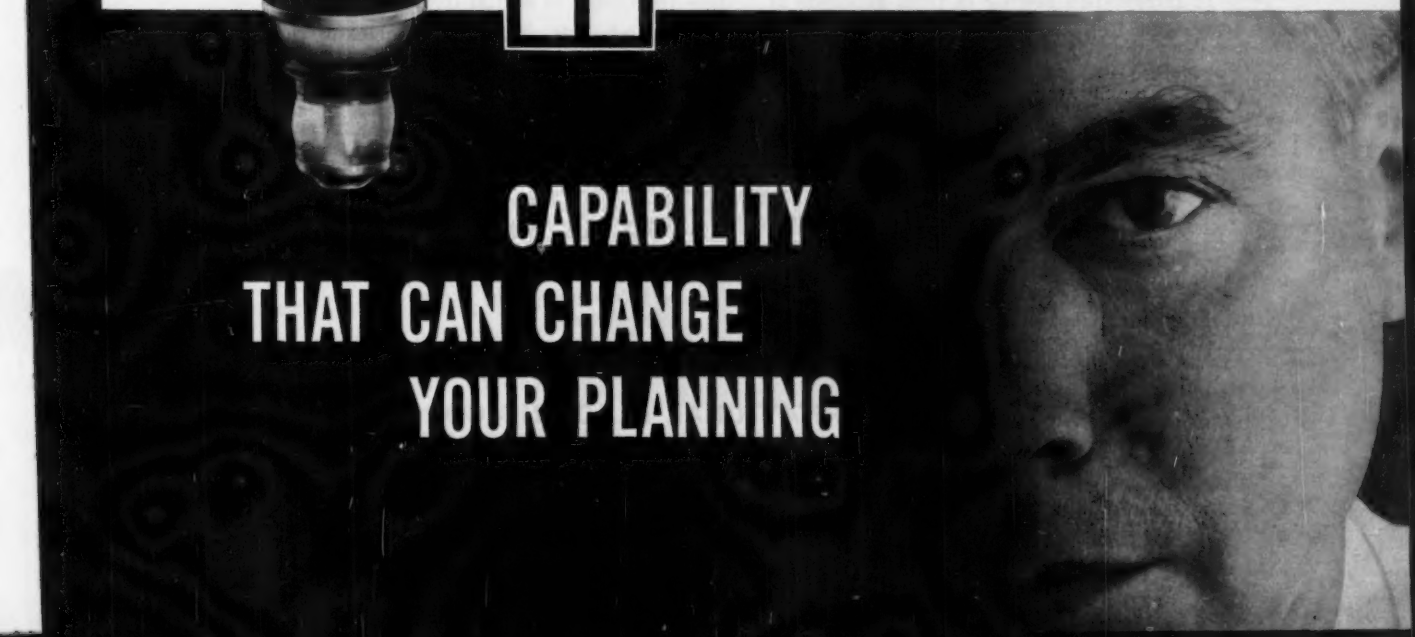

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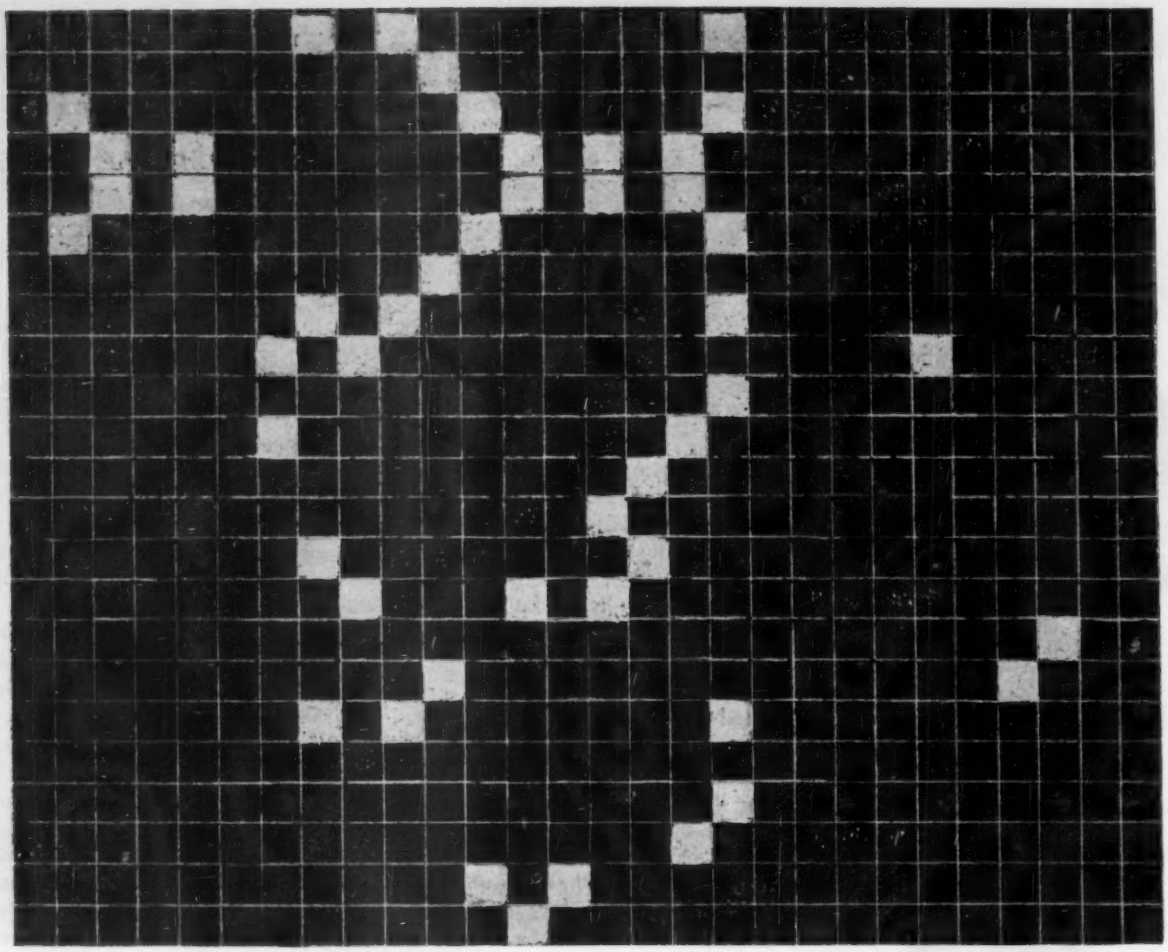

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# Military Buying to Climb

## Commerce Dept.'s electronics division sees a 16-percent hike in sales to services

WASHINGTON—Orbiting Atlas communications satellite has gone far towards balancing the public's psyche in the cold war. By doing this it may help balance the 1960 federal budget as well.

President Eisenhower unexpectedly announced just before Christmas that the 1960 budget would be a balanced one in the "general area of $77 billion," compared to the fiscal '59 budget total of $79.2 billion.

### *Higher Defense Spending*

Although defense and other budget details will probably not be known for a few days, the President stated: "The budget will provide higher expenditures than ever before in time of peace for national defense."

This means that the President plans to go above the estimated $40.8 billion figure for the year ending June 30. There has been talk of increasing the defense outlay to $41 or $42 billion.

Outlook is for boosts in missile production spending despite some missile cancellations, a drastic cut in aircraft production expenditures, and a slight increase for other types of military electronic procurement.

The electronic division in the Commerce Department's Business & Defense Services Administration forecasts a 16-percent hike in military electronic sales. However, it doesn't explain the base figure used.

### *Military Electronic Outlays*

Based on estimates that about 25 percent of aircraft production and 35 percent of missile production go for electronic gear, ELECTRONICS' own estimate is that shipments of military electronic products—as measured by Pentagon cash outlays—will total about $4.2 billion during the current 1959 fiscal year.

Projecting shipments in the new year from this base figure, BDSA's forecast of a 16-percent hike means an increase of some $672 million in expenditures. Actually, BDSA's forecast refers to sales or new orders rather than shipments, refers also to calendar 1959 rather than fiscal 1960. But shipment and new order figures for military electronics have been running close together and Pentagon experts figure the trend to continue.

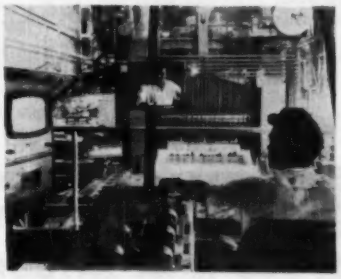
Aircraft outlook is for a drop of about $1 billion in production expenditures in fiscal 1960, bringing the total down to about $6.2 billion. But the electronics slice of the aircraft production dollar, now averaging 25 percent, will increase some. So it's likely that aircraft electronics spending will remain at about this fiscal year's level of at least $1.7 billion.

### *Missile Share*

Missile production expenditures will probably rise by at least $1 billion over the current $3.4 billion volume. And the missile electronic share will go up proportionately from this year's rate of at least $1 billion.

Shipborne electronic expenditures, running at a rate of about $117 million, will continue at the same level at best or dip slightly.

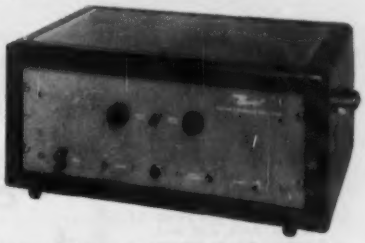
# Controls Ingots



**Closed-circuit tv installed by GE gives mill operator vision he needs to control rolling of white hot, 12,000-lb aluminum ingots at Kaiser plant in Ravenswood, W. Va.**


# NEW BENDIX

## VOLTAGE-CONTROLLED OSCILLATOR FOR MISSILE & INDUSTRIAL APPLICATION



**What it does:** produces a pulsed output whose frequency is proportional to input voltage.

**Where it can be used to advantage:**

- Analog to FM telemetry.
- Driving FM data handling system directly from uncompensated potentiometer sensor.
- Converting EPUT meter to digital voltmeter.
- Providing 0.1% FM readout for voltage sensor.
- Acting as voltage integrator with cumulative counter.
- Checking response of pulse-averaging discriminators.
- As sweep frequency generator when driven by integrator-connected DC amplifier fed with square wave.
- As highly stable, variable frequency trigger source with input potentiometer.
- As reference element in wide band feedback discriminator.

**Its performance characteristics:**

| | |
|---|---|
| Input Range | 0 to +100 volts; d.c. to 1 KC. |
| Output Range | 10 KC to 110 KC. |
| Output Pulse | 0.5 μsec pulse, 0.1 μsec rise time. 80 volts amplitude, either polarity. |
| Linearity | Maximum deviation +0, −0.2% of full scale from straight line through 10 KC and 110 KC. May be corrected to best straight line giving maximum deviation of ±0.1% of full scale. |
| Frequency Response | Response to a step input of any amplitude is within one period of the state frequency corresponding to the step input. |
| Input Impedance | Greater than 1000 megohms at any input level. |
| Stability | Drift over a 24-hour period is 0.1% of full scale maximum after initial warm-up period. |
| Power | 100-125 volts, 60 cycle. |

**For further information write to: Dept. J1-16**

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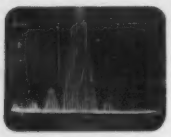
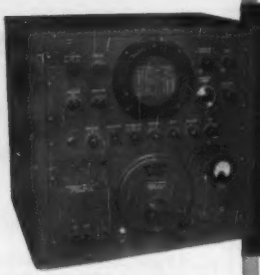


Pulsed radio frequency specifications displayed on SPA-2 screen. Power points, nulls, and assymetries due to improper firing are quickly analyzed.

**200cps** resolution
**high** stability
**low** residual hum

IN ONE **LOW COST** UNIT!



PANORAMIC'S COMPACT
**SPA-2** MICROWAVE SPECTRUM ANALYZER

**How the SPA-2 Does It:**

- 1 mc wide sweepwidth continuously adjustable down to 0
- Variable resolution, 10 Kc to less than 200cps
- Variable sweep rate 1 cps to 60 cps
- Linear, 40db log, and power amplitude scales
- Choice of 2 extremely sensitive, stable tuning heads—RF-5 (50-250mc): 100 dbm, RF-6 (220-4000mc): to —100dbm on fundamentals

Own a reliable tuning head in this frequency range? Then . . . all you need is PANORAMIC's SB-8b Type T1000 Panalyzor (available separately)

the low-cost solution to your spectrum Analysis needs.

Now with the 200 cps resolution featured by the SPA-2 you can examine narrow band (1 mc or less) microwave spectra in fine detail. Half and quarter power points, lobe symmetry and other vital characteristics of broad pulsed RF are reliably delineated scan after scan.

Because the SPA-2 is free from residual FM hum modulation, the IF bandwidth resolution control is *fully usable* to below 200 cps, giving you meaningful envelope patterns.

And that's not all! The versatile SPA-2 can also be used to analyze: Standard AM & FM systems, noise spectra, oscillator instabilities . . . and many other dynamic phenomena. All this performance is yours at extremely low cost, too. Write, wire or phone *today* for the full story . . . specifications, applications, prices.

*dependable* CERTIFIED SPECIFICATIONS *for accurate data*

PANORAMIC RADIO PRODUCTS, INC.

Send for Panoramic's 1959 CATALOG DIGEST and ask to be put on our regular mailing list for the PANORAMIC ANALYZER featuring application data.

**PANORAMIC RADIO PRODUCTS, INC.**
**530 So. Fulton Ave., Mount Vernon, N. Y.**
**Phone: OWens 9-4600**
Cables: Panoramic, Mount Vernon, N. Y. State

## MEETINGS AHEAD

**Jan. 29-30:** Long Distance Transmission by Waveguides, Institution of Electrical Engineers, London, England.

**Feb. 1-6:** American Institute of Electrical Engineers, Winter General Meeting, Statler Hotel, N.Y.C.

**Feb. 12-13:** Transistor & Solid-State Circuit Conf., AIEE, PGCT of IRE, Univ. of Penn., Philadelphia.

**Feb. 12-13:** Electronics Conference, AIEE, IRE, ISA, OPS, Eng. Soc. Bldg., Cleveland.

**Feb. 17-20:** Western Audio Convention, Audio Eng. Soc., Biltmore Hotel, Los Angeles.

**Mar. 3-5:** Western Joint Computer Conf., AIEE, ACM, IRE, Fairmont Hotel, Los Angeles.

**Mar. 5-7:** Western Space Age Conf. and Exhibit, L. A. Chamber of Commerce, Great Western Exhibit Center, Los Angeles.

**Mar. 15-18:** National Assoc. of Broadcasters, Annual Convention, Conrad Hilton Hotel, Chicago.

**Mar. 23-26:** Institute of Radio Engineers, IRE National Convention, Coliseum & Waldorf-Astoria Hotel, New York City.

**Mar. 31-Apr. 2:** Millimeter Waves, Symposium, Polytechnic Inst. of Brooklyn, USAF, ONR, IRE, USA Signal Research, Engineering Societies Bldg., N.Y.C.

**Apr. 5-10:** Nuclear Congress, sponsored by over 25 major engineering and scientific societies, Public Auditorium, Cleveland.

**Apr. 13-15:** Protective Relay Conf., A & M College of Texas, College Station, Texas.

**Apr. 14-15:** Industrial Instrumentation and Control Conf., PGIE of IRE, Armour Research Foundation, Illinois Inst. of Tech., Chicago.

**Apr. 16-18:** Southwestern IRE Conf. and Electronics Show, SWIRECO, Dallas Memorial Aud. & Baker Hotel, Dallas.

**May 3-7:** Semiconductor Symposium, Electrochemical Society, Philadelphia.

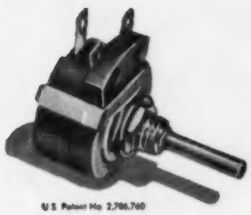
There's more news in ON THE MARKET, PLANTS AND PEOPLE and other departments beginning on p 82.

OFFICIAL U.S. NAVY PHOTOGRAPH

# Demonstrated Precision and Reliability

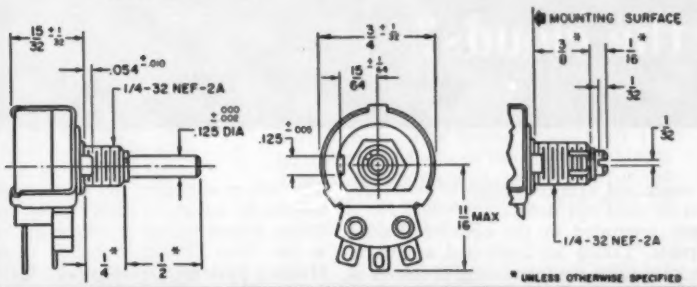
Clarostat Series 49M Miniaturized Wire-Wound Potentiometers are used in the critical electronic system of the famous air-to-air Sidewinder missile. This is one more example of Clarostat precision — precision you can count on.

## CLAROSTAT MINIATURIZED WIRE-WOUND POTENTIOMETERS



U.S. Patent No. 2,786,760

Precision wire-wound potentiometers designed for the most critical military and commercial use where space is at a premium, yet there can be no compromise with reliability. Clarostat Series 49M Potentiometers are available in single or dual units and may be ordered in encapsulated models for maximum resistance to moisture or other ambient conditions. Ordering variables include: resistance and tolerance; function characteristics; bushing length; shaft length and configuration and relation to contact; locating pin position; and construction.




### SPECIFICATIONS

**Power Rating** — 1.5 watts @ 40° C.
**Insulation Breakdown Test** — Between terminals and ground for 1 minute, 1000 V ac @ 3.4" Hg.
**Resistance Range** — 1 to 20,000 ohms.
**Resistance Tolerance** — ±5%
**End Resistance** — In accordance with MIL-R-19 specifications.
**Tapers** — Linear only.
**Mechanical and Electrical Rotation** — 300°, ±3°
**Effective Rotation** — 300°, ±3°
**Torque** — 0.5 to 3 oz. in. (Also available with locking type bushing up to 20 oz.in.)

CLAROSTAT

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**CLAROSTAT MFG. CO., INC.,** DOVER, NEW HAMPSHIRE

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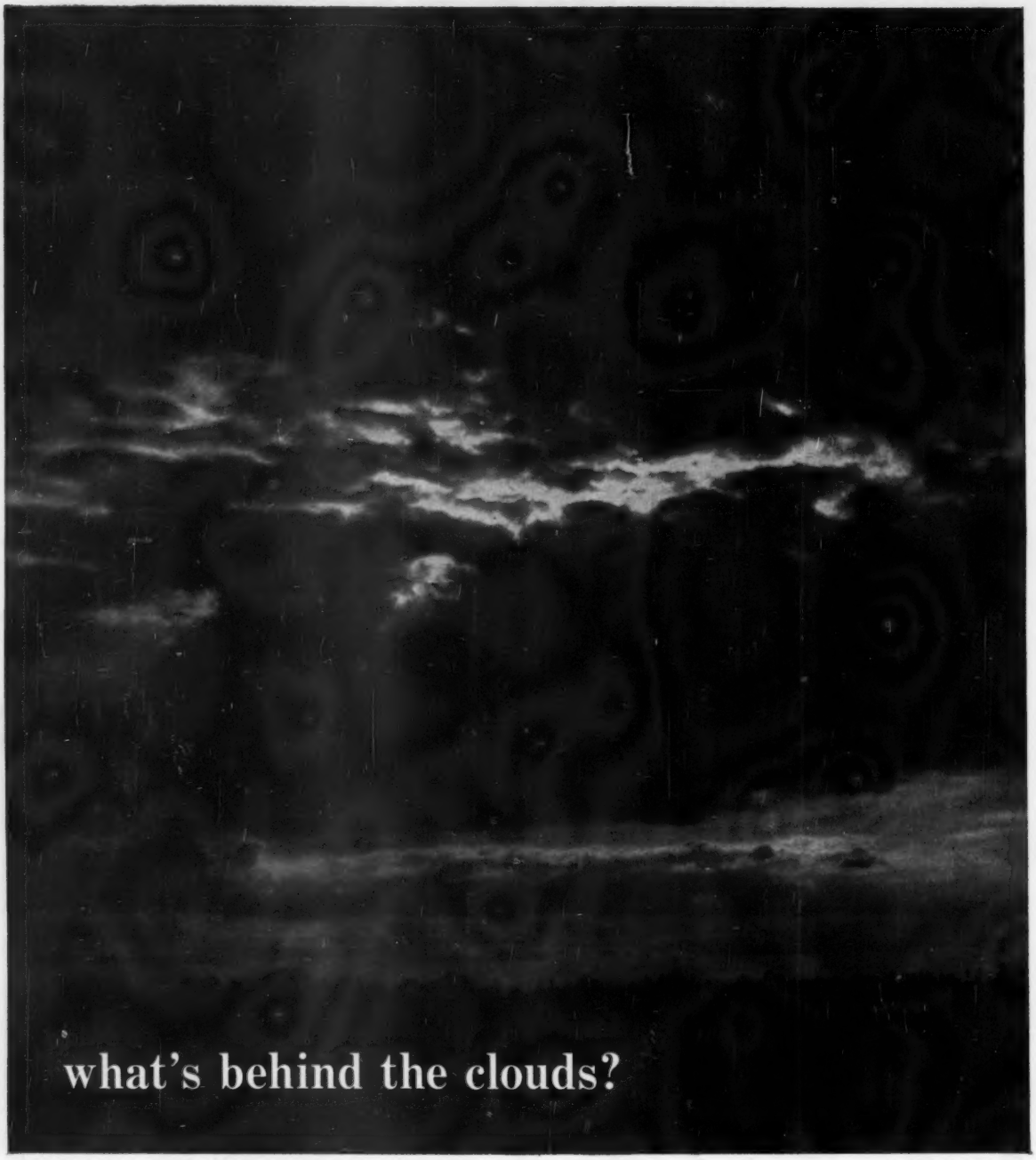

# what's behind the clouds?

BEHIND THE CLOUDS hides a cunning enemy with ever-improving weapons to threaten our security. To deter these airborne aggressors is the job of the all-weather interceptor, our first line of defense.

Partaking in a giant chess game, a Hughes Airborne Systems Engineer is constantly fed intelligence information regarding the most recent enemy advances. He asks the question, "How effective are present interceptors against the new enemy capabilities, and how can we counter this challenge?"

The Hughes Airborne Systems Engineer is concerned with the design of hardware, but he does not design hardware. He is more interested in the broader systems aspects. Taking an analytical approach, he must solve the interacting problems of performance, reliability, maintainability, and operability.

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SYSTEMS DESIGN • SYSTEMS FLIGHT TEST
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The salary structure for these positions reflects the advanced nature of the assignments. Please inquire by writing directly to Dr. Allen Puckett, Associate Director, Hughes Systems Development Laboratories.

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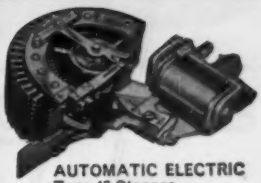

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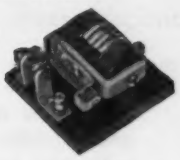

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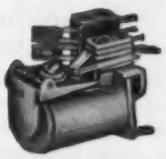

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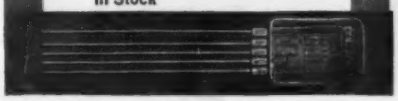

(Actual Size)
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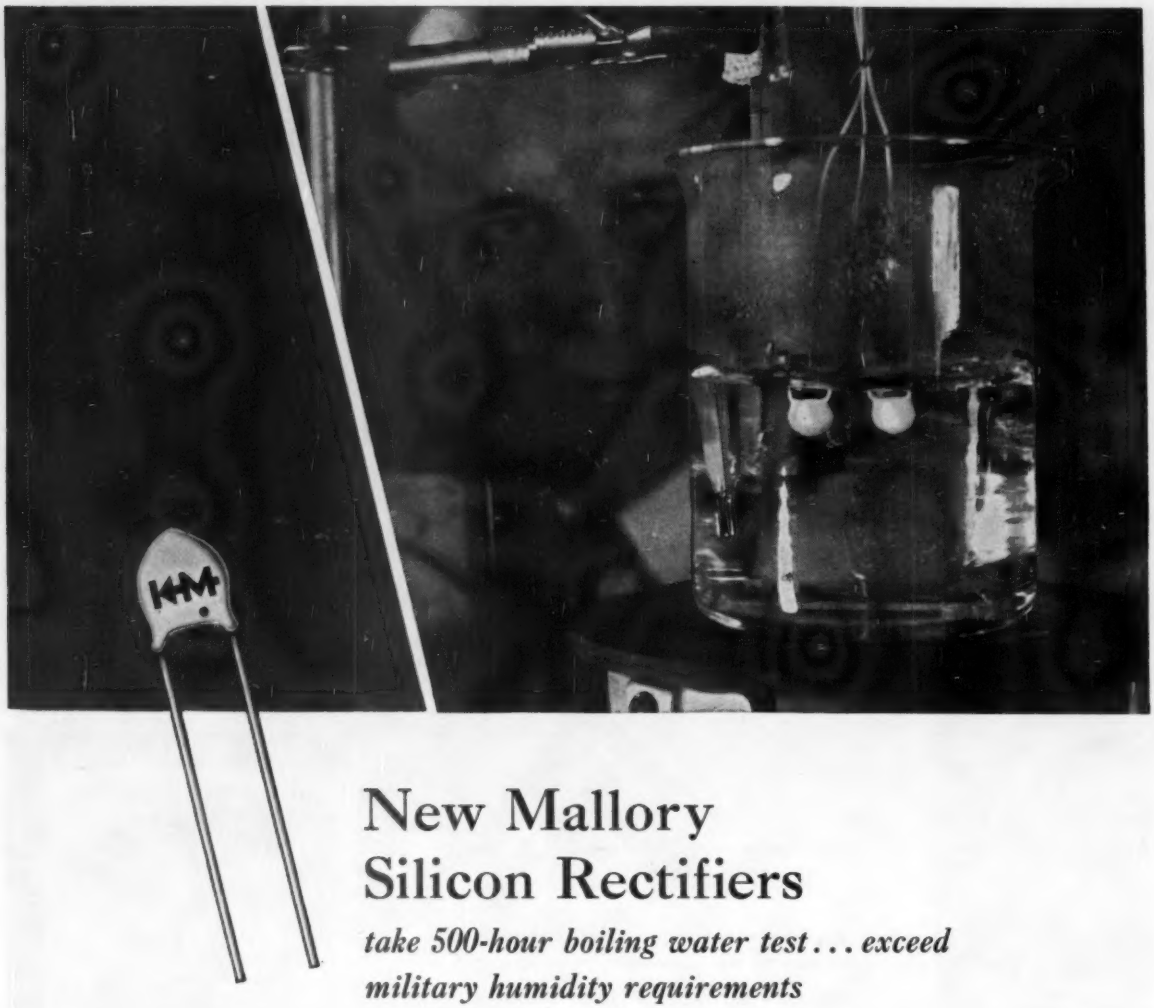



# New Mallory Silicon Rectifiers

***take 500-hour boiling water test . . . exceed military humidity requirements***

Here, for the first time, is a silicon rectifier proved to have superior reliability and humidity resistance, and priced for radio and television use. It's the new Mallory Type T—a major break-through in semi-conductor technology!

**NEW MOISTURE-PROOF DESIGN.** Unique Mallo-Seal* encapsulating material, created by Radio Materials Company, a Mallory division, enables the Type T to withstand 500 hours of boiling water test —to pass *four times* the humidity cycling of MIL-202A—without deterioration.

**NEW PERFORMANCE.** Reverse leakage current is less than 250 microamperes—forward drop less than 0.5 volt—at 85° C ambient and 0.5 amperes forward current. Characteristics stay virtually unchanged on 2000-hour life test above 85° C ambient and 1.5 million cycles of switching at rated load.

**NEW RELIABILITY.** Unique production and automatic 100% testing methods end premature failure problems.

**NEW ECONOMY**— priced substantially lower than commercial silicon rectifiers.

**Trade Mark, P. R. Mallory & Co. Inc.*

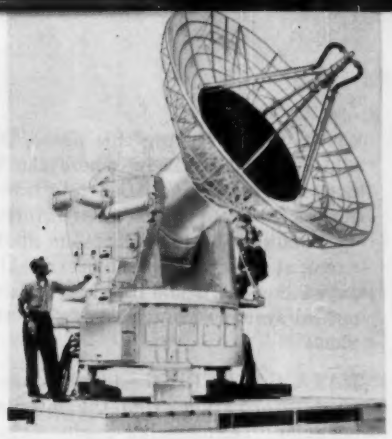
**Plug-in model,** for fuse type clip mounting, is also available. Characteristics are the same as the Type T described above.

P.R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

electronics
JANUARY 16, 1959



AN/FPS-16 instrumentation radar (above) and Sandia tracking telescope (at right) are two of the high-precision systems in use on the Atlantic range

# Instruments: Key to Missile Programs

## Range instrumentation calls on all the techniques of measurement in several sciences. Electronics and optics get rapid and complete data to guide guided-missile development

By **FRANK LEARY**, Associate Editor

LAST SEPTEMBER, several destroyers on maneuvers in the North Atlantic, two cruisers resting at anchor in Charleston, S. C., the carrier *Roosevelt* at berth in Norfolk, Va., and a couple of atomic subs were ordered "at flank speed" to rendezvous near the Bahamas.

The purpose: to flush unidentified subsurface craft known to be lurking in the waters off Florida. Or to force them to keep their antennas submerged during critical missile firings about to take place.

Every time a missile is fired from Cape Canaveral, the Caribbean airwaves hum with data as hundreds of millions of dollars worth of electronic gear goes to work. This country's vital missile programs rely on the electronics technology for data. This is the story of how that information is gathered, and of the part electronics plays in the deadly game of guided missiles

RANGE INSTRUMENTATION is an extensive field of applied technology which has grown entirely in the years since World War II.

During these years, the concept underlying the nation's defense plans has changed. The quantitative superiority that was the aim of 1945's tanks, planes and ammunition has been replaced by the aim of qualitative superiority in armanent such as long-range nuclear-armed guided missiles.

Such armanent dictates simultaneous development and production of weapons systems, and makes the rapid feedback of test information a critical need. This requirement has spurred the growth of the new field of range instrumentation.

Missile test ranges to collect test data and feed it back to development groups vary in size from Navy's short ranges at Dover, N. J., and Chincoteague (Temperanceville), Va., to the 5,000-mile Atlantic range

**FIG. 1—Atlantic Missile Test Range stretches 5,000 miles from mainland to Ascencion Island**

beginning at Cape Canaveral, Fla. The ranges differ principally in scale, in magnitude and complexity.

The Air Force Missile Test Center at Patrick Air Force Base conducts flight tests on all Army, Navy and Air Force missiles designed to fly over 150 miles. Chincoteague and Dover handle missiles intended to reach a target within a few miles. The Air Force's $150-million-plus investment in information-gathering facilities at Canaveral dwarfs all other ranges currently in operation.

**CAPE CANAVERAL**—The Air Force Missile Test Center in Florida is launch point for the Atlantic missile range. Recording equipment covering the missile flights from Canaveral is situated at a series of auxiliary air bases extending from the Florida mainland to St. Lucia in the Windward Islands, thence to Fernando de Noronha off the coast of Brazil, and on to Ascencion Island (see map, Fig. 1).

The 3,500-mile skip between St. Lucia and Ascencion is also watched from six permanently anchored telemetry picket ships. These ships are used mostly on tests of air-breathing missiles. Angular position data derived from the pickets is accurate only within 15 degrees.

Data-processing gear is centrally located at Patrick AFB. The raw data entering the reduction facility becomes a complete flight-test report within about ten days after a flight.

Instrumentation on the Atlantic range is planned, engineered and operated under the management of RCA Service Co., which subcontracts the job from range manager, Pan American World Airways.

**FLIGHT PHASES**—A missile flight is considered as having three distinct phases: launch, midcourse, and terminal flight.

Launch includes everything from before the countdown to burnout. During this period, everything that happens to the missile is measured to a high degree of precision. Optical systems are used in the actual launch area; at 2,000 to 3,000 ft up, when the ground clutter ceases to be a nuisance, electronics starts to work.

From burnout to reentry, the missile is in its midcourse flight. During this phase, the ground-control station needs to know where the bird is, but does not require precision. Coasting time is most valuable for reception of telemetered information.

From reentry to impact, the need for exact measurement arises again. The terminal trajectory is the payoff for the whole flight. Precision electronic and optical systems are used to follow the missile in this phase.

**DATA GATHERING**—In all stages, the engineers need information from the missile on its internal behavior. Telemetering begins prior to launch, goes on throughout the flight. Launch-phase information of particular interest includes the functioning and behavior of valves, engine, guidance system, fuel utilization system. If a stage separates at burnout, that process is also metered. In the terminal phase, the measurement of the warhead environment and operations of the fuzing and arming devices are of critical importance. Throughout the flight, vibration, pressure, temperature and fuel supply are continually monitored.

Recorders aboard missiles that have flopped on the skid strip at Canaveral have provided even more data than telemetry units. Atlas, Jupiter and a couple of other missiles carry small tape recorders in their nosecones that eject themselves seconds before impacts, parachute into the sea, and as they float signal for help until they are recovered.

Chase planes frequently tag along after air-breathers to take closeup photos on the midcourse run. The only known unintentional collision of a missile with a plane involved a Snark and an Air Force jet chase craft with an RCA cameraman aboard. The wing of the jet was damaged, but it limped 125 miles back to Patrick. The Snark sank.

**TIMING SYSTEM**—Precise timing is one basic requirement for the accurate measurement of missile position and behavior. Timing codes used throughout the missile test are produced electronically as trigger pulses or in binary-code form. Most codes are presented serially in a form that can be recorded directly by magnetic or photographic equipment. All codes can be sampled once a second and read out in Eastern Standard Time.

Master control of the timing system is located at Canaveral. Two identical timebase generators produce identical codes from a 64-kc clock frequency synchronized to 0.1 microsecond with WWV. An electromechanical sequencing device triggers the timebase generator at the first motion of the missile. The same sequencer triggers the 30-odd cameras in the immediate launch area, and also programs certain internal missile functions during countdown.

Timing signals are transmitted to all outlying stations on the Florida coast by wire or radio. They are sent downrange by submarine cable (which terminates at Mayaguez, P. R.). The signals are distributed in low-energy form, and are amplified, reshaped and retimed in terminal units at each downrange using point.

The 64-kc clock frequency can maintain its one-

part-per-million stability over long periods. Throughout most of the range, timing is synchronized to within 150 microseconds. Beyond the submarine cable, the timing signals are relayed by radio link; at the more remote downrange points, timing is synchronized to within 250 microseconds.

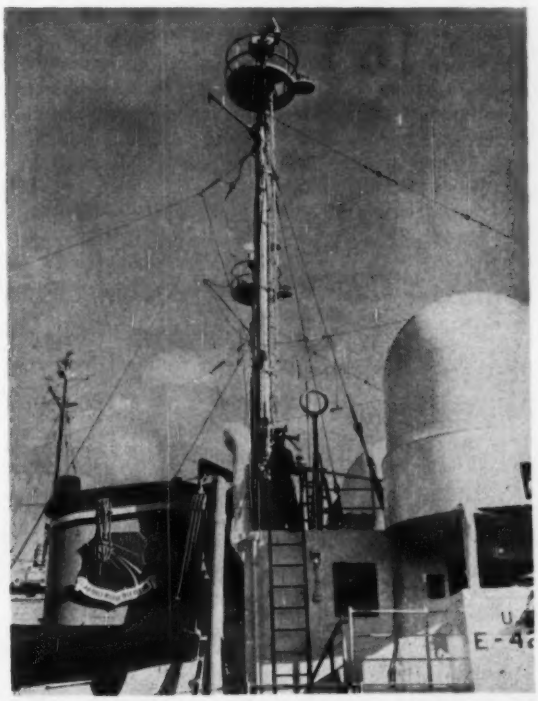
The identical timebase generators at Canaveral provide 100-percent backup. Each works all the time, but only one is connected at a time to the distribution system. If the in-service generator fails, the communication line carrying the signals is immediately and automatically switched to the other unit.

Each downrange station has its own timing generator, which is synchronized with the master unit in Florida. If the local generator fails, the synchronizing signals coming in over the cable or radio link are switched in and used. Portable subcentral units are used at remote points on the range.

**COMMUNICATIONS**—Reliable communications are another basic requirement for operation of the test range.

Primary link between the mainland and all downrange stations as far as Mayaguez, P. R., is a single-conductor submarine cable. This cable may later be extended to Antigua, B. W. I. The cable carries 12 channels in each direction, of which 10 can be used by the range for voice, teletype or data transmission, as needed. Carrier techniques are used for multichannel operation.

H-f, vhf and uhf radio are used for communication between individual stations and sites not on the cable, as well as from stations to ships and aircraft. Radio links the six telemetry pickets into the system.



Radomes and mast-top tracking antenna on one of the six telemetry ships

Before and during flights, the entire radio spectrum from 2 to 10,000 mc is regularly monitored. Interference-control equipment measures electromagnetic radiation, to try to hold interference to an acceptable level. Most of this equipment—airborne and land-based panoramic receivers and recorders—is adapted from similar reconnaissance and ferreting gear used in the electronic countermeasures field.

**SAFETY**—Range safety and surveillance, too, depend on electronics. Air Force FPS-8 radars inspect the airspace above the range from Canaveral and Grand Bahama before a missile shoot. The ocean areas in which the missile or its boosters may fall are inspected prior to firing and during the missile flight by air early warning radar of the AN/APS-20 type. Video information obtained by the AEW craft is transmitted to ground by vhf radio link, and both displayed and manually plotted for the range safety officer.

If a missile becomes hazardous in flight, the safety officer can destroy it. A uhf command control and destruction system can radio as many as 20 different coded commands for control purposes, including the "destruct" command. The command control is a dual-channel system to provide 100-percent backup. It is also fail-safe: interruption of the carrier signal destroys the missile.

During the launch phase, an IBM704 at Canaveral is fed either by the high-precision Azusa c-w system or the AN/FPS-16 radar. Both inputs come into the computer central; the man in charge can pick whichever seems most accurate. The computer continually predicts where the missile would land if power were to be cut off on the instant. This permits the range safety officer to take early action in case of malfunction.

ELSSE skyscreen or Dovap phase-comparison systems watch the missile as it lofts to make sure it departs downrange on the right azimuth. One watches it from behind, another from across its path; the two outputs are displayed for the safety officer.

**RADAR**—Tracking radar used at the launching site and at each downrange station is an extensively modernized SCR584, referred to as AFMTC Model II. Two of these updated artillery workhorses are installed at each station. The Mod II system can reach out several hundred miles for targets, can measure angles to one-mil accuracy. Modification includes coordinate converters (polar to rectilinear), automatic plotting boards, digital-data recorders and data-transmission gear. Random and systematic errors can be corrected through additional data gleaned from boresight cameras mounted on each Mod II reflector.

Potentiometer and synchro outputs are the analog data produced by the Mod II. Potentiometer outputs giving azimuth, elevation and slant range are converted to rectilinear analogs, then fed to converters

Azusa, developed by Convair, is a highly accurate c-w phase-comparison system. Antenna array measures angle cosines

to operate pens on automatic plotting boards.

Commutators on the shafts of the radar's azimuth and elevation indicators produce digital versions of the angular data. The digital information is stored and sampled at half-second intervals. Outputs are recorded on punched-paper tape for later processing in a digital computer.

The digital position information, corrected for parallax, is also relayed downrange to help other stations acquire target, and sent back to central control at Canaveral to afford a continuous plot as the missile passes over each tracking station.

Highly precise AN/FPS-16 tracking radars are also used, with installations at Canaveral, Grand Bahama and Ascencion, and one going in at Eleuthera. The RCA-built FPS-16 is a more sophisticated and more accurate radar, with a longer tracking range than the Mod II.

**C-W SYSTEMS**—Continuous-wave systems such as Azusa, Dovap, Cotar and Secor are used to pinpoint missile position during launch and terminal phases.

Dovap (doppler velocity and position) starts by transmitting a c-w signal which is picked up by the missile, doubled, and retransmitted to ground. Three ground receivers on a precisely surveyed baseline pick up the original signal and double it, then beat the doubled signal against the incoming signal from the missile. Dovap transmitters are installed at Canaveral and Grand Bahama.

Azusa is a byproduct of the Convair MX-774 project (forerunner of Convair's Atlas ICBM). It is an enormously complex interferometer, and is an extremely accurate phase-comparison system. It uses only one ground station and a small missileborne transponder. Ground station has a compact array of nine antennas, eight of which are receiving antennas arranged in the form of a big cross. U. S. Coast & Geodetic Survey located the antennas to an accuracy of 2½ parts in a million.

Antennas are housed in air-conditioned plastic radomes, securely footed in massive watercooled concrete pads to limit movement from vibration and heat expansion. Major missile launching pads are surveyed with reference to the Azusa baseline.

The Azusa ground station broadcasts a modulated c-w signal which is rephased by the transponder and rebroadcast. The cruciform antenna array permits measurement of angle cosines, provides position data in digital form to an accuracy of 34 parts in a million, or 0.1 mil.

**OPTICS**—During the first few thousand feet of the launch phase, and in the last moments before impact, the most valuable data are provided by optical systems.

Tracking theodolites simultaneously record pictures of the missiles, their own azimuth and elevation pointing angles, and the master timing code. A fix from two theodolites accurately surveys the missile's position in space; changes in position with respect to time produce velocity and acceleration data.

Standard motion-picture cameras modified to record timing codes as well as the missile picture augment the theodolite data. These cameras are primarily used for recording specific events with relation to time. One type of camera takes 800 to 1,000 pictures a second of the exhaust flame of the rising missile for later analysis. The camera could take as many as 6,400 frames a second.

Fixed cameras are extensively deployed around the launch site to record metric and engineering data in the early stages of flight. Each camera is preoriented at a carefully calculated angle so that the missile will pass through its field of view.

Highly accurate ballistic-plate cameras photograph missiles during the launch and terminal phases of nighttime shoots. These cameras record the image of an intense flashing light aboard the missile against the background of star trails. A fix from two or more of these cameras provides unusually accurate space-position data, since star positions are known to high orders of accuracy. The ballistic-plate cameras measure to accuracies of 1 part in 50,000.

**TRACKING** — Perkin-Elmer's recording optical

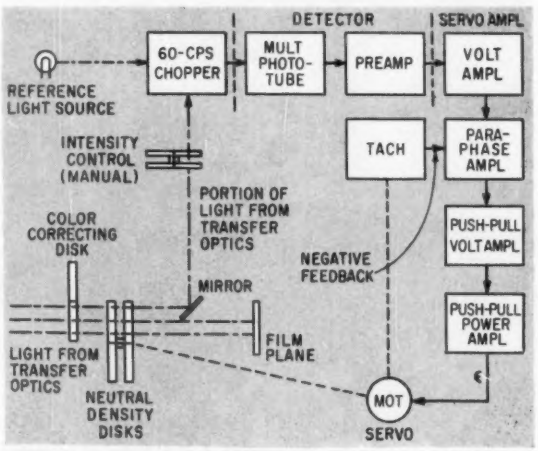



FIG. 2—ROTI automatic exposure control

tracking instrument (ROTI; see cover) has recently been added to AFMTC's armory of optical range instruments. ROTI is a telephoto cine camera whose principal purpose is to record booster separation at slant ranges of 100 miles or more. It is basically a Newtonian telescope with a 24-in. aperture and a focal length variable in 100-in. steps from 100 inches to 500 inches. It took pictures of Sputnik II at a distance of 200 miles with sufficient clarity to allow scientists to calculate the satellite's length.

Pointing of the telescope is normally under the control of two operators, one controlling azimuth aided-tracking system, the other elevation. It can also be controlled by one man in the elevation-operator's position. Original target acquisition, however, is slaved to a radar through computing circuits and a coordinate converter. The same converter provides slant-range-to-target to control the focus.

For exposure control, external light levels are compared with a reference light source (see Fig. 2). The two light sources are alternately admitted to a multiplier phototube by a mechanical chopper. Output from the phototube is amplified to servo a pair of variable-density disks which turn to control the amount of light admitted to the camera. (The ROTI operates always at critical aperture to maintain high resolution.) The two neutral disks are placed between the transfer optics and the film, can vary light intensity between 0.1 percent and 100 percent of the light energy entering the telescope objective.

**TELEMETRY**—In-flight data of interest to missile engineers are obtained by telemetry. Eighteen f-m/f-m subcarrier channels are available for each r-f telemetry carrier. Nine of these can be commutated in 27 subchannels, giving each carrier a capacity of 252 functions. Common practice uses as many as 600 channels or subchannels for a single missile flight, producing several miles of tape records.

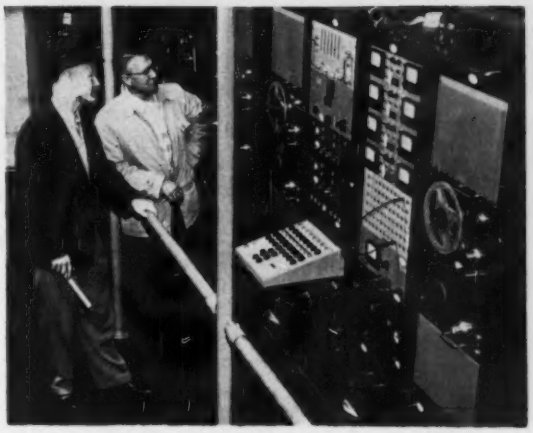
Ground stations receive the signals, separate the subcarriers, decommutate subchannels where needed, and record each subchannel. Engineers may monitor directly any of a score or more preselected functions throughout the test flight.

The composite signal is also recorded directly by precision magnetic-tape recorders. Telemetry recorders are in operation at all stations on the range and in the picket ships.

Tapes are later played back on automatic data-reduction equipment, and graphs are made of the individual functions. During this process engineers can correct for nonlinearities in the transducers.

Ground receivers use standard 3- and 7-turn helical antennas. RCA expects to be able to span the whole 5,000 miles from four stations within the near future by use of high-gain automatic tracking antennas built by Radiation Inc. of Melbourne, Fla. These new systems will use 60-ft reflectors, will deliver a gain of 24 to 28 db over isotropic systems.

**DATA-PROCESSING** — The end product toward which the entire range works is data. Following tests, the recorded information from sites at the launching area and downrange is rushed to the central data-reduction facility on the mainland. Photographic film, paper tape and magnetic tape are each processed separately; meteorological and survey data are also processed by separate groups.



**Telemetry recorders on downrange picket ships**

Magnetic-tape records from radar and telemetry stations are immediately scanned for identifying symbols, orientation blocks, time indicators. Film is developed and edited; the film data are then subjected to sample evaluation runs on desk calculators, using prepared station constants. If results are reasonable and agree with anticipated results, the film data are transferred to paper tape and scheduled for complete processing in an automatic digital computer.

Paper tapes generated at sites measuring trajectory electronically are edited and correlated with photographic boresight data. The tapes are repunched on automatic recording typewriters to ensure correct format and make allowances for bad data spots. The verified tapes are then passed along to the computer.

Meteorological data relating to conditions at launch time are assembled to compute the index of refraction. This computed index is then used as a correction factor in trajectory computation. Survey information is obtained either just prior to or just after a test and is used to compute station constants: exact location of instruments and target boards (used to orient and calibrate optical instruments), origin point of the missile, camera lens specifications, meteorological factors and earth-curvature corrections.

Heart of the data-processing facility is the FLAC (Florida automatic computer). This is a relatively high-speed tape-fed digital computer with fast magnetic-core storage for 4,096 15-bit words. The IBM704 used during tests for impact prediction is used as an auxiliary processing system. Another FLAC is now under construction at Patrick.

Within 48 to 72 hours, virtually all information from a test has been processed and is ready for release in preliminary form. The output tapes from the computer are printed out by automatic typewriters. The typed pages are multilithed for final distribution to contractors and government agencies within 10 to 12 days.

**Voltage-tunable ferroelectric capacitors are being applied to a variety of practical circuits such as f-m oscillators, panoramic receivers and afc systems. Presently available materials permit operation at sweep rates up to 100 kc and tuning up to 250 mc. Direction research must take to expand their use to higher frequencies is discussed and manufacturing methods described**

By THOMAS W. BUTLER, JR.,

Associate Research Engineer, Electronic Defense Group, University of Michigan, Ann Arbor, Mich.

# Ferroelectrics Tune

FERROELECTRIC capacitors are making it possible to construct a greater variety of electrically tuned circuits. Electronic frequency control is flexible, versatile and, in many applications, essential. Therefore, ferroelectric-tuning techniques are being applied to sweep generators, spectrum analyzers, panoramic receivers, f-m oscillators, harmonic generators.

This article discusses ferroelectric capacitors and their use in the design of sweeping, low-power, vhf and uhf oscillators; an electrically tuned f-m oscillator; an electrically tuned panoramic receiver for the 35 to 200-mc range; and an automatic frequency-control device. Problems encountered in the construction and application of ferroelectric capacitors as frequency-controlling devices are included.

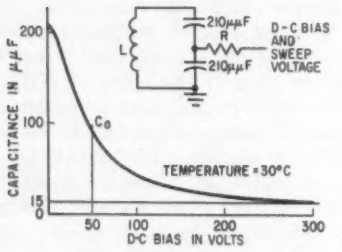



**FIG. 1—Ferroelectric capacitors are connected in parallel with bias and sweep voltages but in series with r-f voltage to keep low r-f field across each capacitor. Plot shows capacitance against bias voltage with $C_0$ the operating point**

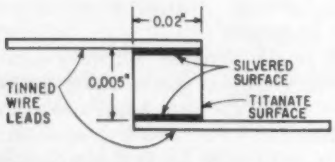



**FIG. 2—Construction diagram shows silvered surfaces on which leads of capacitors are soldered**

### Tuning Elements

Electric tuning techniques use the nonlinear electrical characteristics of certain types of ferroelectric materials. Barium strontium titanate materials constitute the major class of dielectrics that are presently being applied to ferroelectric tuning devices. Capacitance is varied by changing the electric field applied to the capacitor.

As shown in Fig. 1, the resonant frequency of a voltage-tunable tank circuit may be controlled by applying a variable d-c bias voltage to the junction of the two capacitors with a ground return at one end of the coil. The d-c bias voltage defines the operating point $C_0$. To sweep the tank in frequency, an a-c signal (60-cps sine wave) is superimposed so that it will vary the capacitance about the operating point.

The two capacitors are connected in parallel with the bias and sweep voltages but in series with the r-f voltage. This arrangement helps maintain a low r-f field across each ferroelectric capacitor while holding the required polarizing field to values that are reasonable.

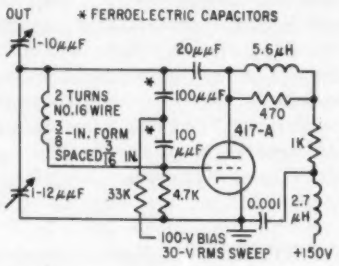



**FIG. 3—Vhf swept oscillator has tuning ratio of about 2 to 1 from 20 to 250 mc and about 1.5 to 1 from 250 to 400 mc**

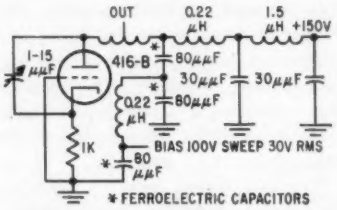


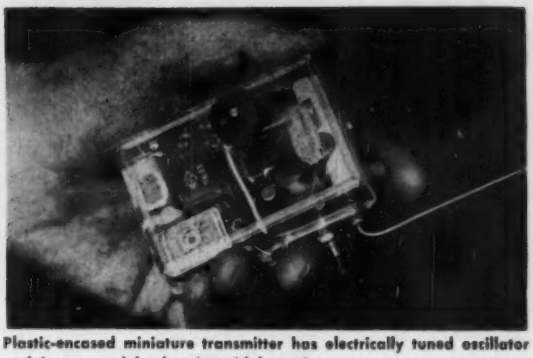

**FIG. 4—Lumped-constant technique was used in designing vhf oscillator that delivers about 10 mw into 50 ohms**

The Q's of the tuning elements increase with an increasing biasing field. Since frequency also increases with increasing biasing field, the Q remains fairly constant from 20 to 250 mc.

### Construction

In constructing capacitors that can be used in practical circuits, a flat disk of Aerovox HI-Q body 91 ceramic material is used. It is provided with silvered electrode sur-

Panoramic receiver using electrically tuned capacitors sweeps between 35 and 200 mc. Frequency change with time is linear



Plastic-encased miniature transmitter has electrically tuned oscillator and is powered by hearing-aid batteries

# Electronic Circuits

faces, as shown in Fig. 2. The silver electrodes are rubbed with a soft solder to facilitate later soldering operations. The disk is attached to a glass microscope slide with wax to provide mechanical rigidity during handling.

The ceramic disk is then diced with an abrasive wheel. The size of the dice depends on the capacitance desired. For vhf applications, 0.005-in. thick material is diced about 0.015 in. on a side. The dice are then removed from the microscope slide by dissolving the wax, and the ceramic squares are washed and spread out over the working area.

A short length of stranded wire is stripped of about one inch of insulation at one end, and the strands are fanned out. The wires are then rolled flat and the ends tinned. The dice are then picked up one at a time by placing the wire strands against the silver electrode and holding a small soldering iron about a quarter inch from the end of the wire strand. The solder flows down the wire and sweats the ceramic cube into place.

After the second wire is similarly attached, the units, which are still attached in a bunch to one wire, are washed in toulene and acetone. They are then separated and potted in a plastic bead. The plastic coating seals out moisture and adds mechanical strength, preventing excessive losses and possible electrical breakdown.

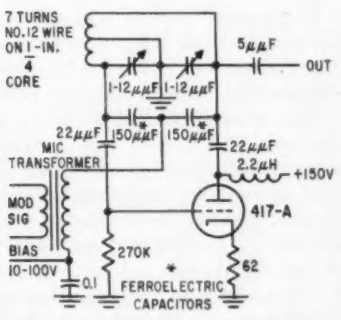



FIG. 5—F-m oscillator uses ferroelectric capacitors for tuning as well as for modulating

### *Sweeping Vhf-Uhf Oscillators*

The circuit shown in Fig. 3 is an electrically tuned, wide-range, vhf low-power swept oscillator that operates up to 400 mc. Such oscillators have tuning ratios of about 2 to 1 in the range 20 to 250 mc and about 1.5 to 1 in the range from 250 to 400 mc.

A lumped-constant, electrically tuned, low-power oscillator circuit, suitable for operation in the vhf region, is shown in Fig. 4. The oscillator uses a 416-B triode in a grounded-grid circuit. The capacitor tuning elements use low-loss, low-inductance, strap-type leads. The tuning ratio in the range from 600 to 1,200 mc is 1.35 to 1. Output power of approximately 10 mw into a 50-ohm load is obtainable throughout the range.

The oscillators shown in Fig. 3 and 4 are suitable for local oscillators in panoramic-receiver design. Although in the panoramic receiver they are swept at a relatively slow rate, there are applications for which a faster scan rate may be desirable. Judging from the relaxation measurements on several samples of titanate ceramics, the upper practical limit of

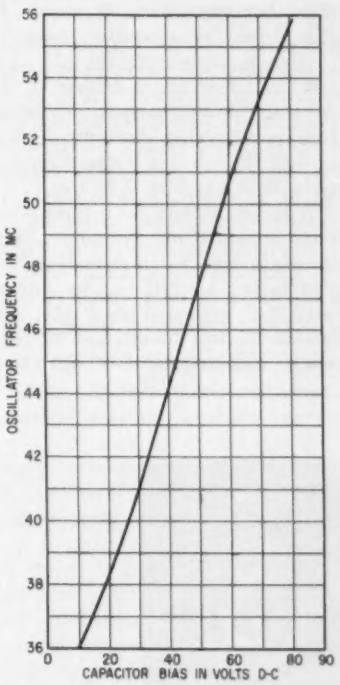



FIG. 6—Plot of frequency against bias shows linear relationship between the two in f-m oscillator shown in Fig. 5

sweeping appears at present to be about 100 kc.[1] For smaller deviations, scan rates have been reported up to 500 kc.[2]

### *Electrically Tuned F-M Oscillator*

The electrically tuned f-m oscillator shown in Fig. 5 was constructed to demonstrate the feasibility of using ferroelectric capacitors as both tuning and modulating elements. As in the case of the low-power, swept, vhf oscillator, the tuning and modulating element is composed of two ferroelectric capacitors. They are connected in series with respect to r-f and in parallel with respect to the tuning and modulating voltages. The highly linear relationship between oscillator frequency and applied tuning voltage is shown in Fig. 6 for this frequency range.

It is possible with the aid of a spectrum analyzer to determine the dynamic measurements of deviation by observing the roots $J_n(M_f) = 0$ of the various Bessel function plots shown in Fig. 7 and 8.

A series of plots for a 40-kc sine-wave modulating frequency are shown in Fig. 7. In each case, the modulation amplitude was varied until the indicated root was obtained. It was found that the dynamic measurements of deviation vs modulation amplitude checked the static characteristics (Fig. 6) quite closely. For example, a peak 40-kc sine-wave modulating voltage of 1.8 volts was required to obtain the spectrum opposite $J_0(M_f) = 0$. From the Bessel function tables, the value of $(M_f)$ at $J_3(M_f) = 0$ is 8.78. Thus the deviation of this spectrum is 8.78 × 40 kc = 350 kc.

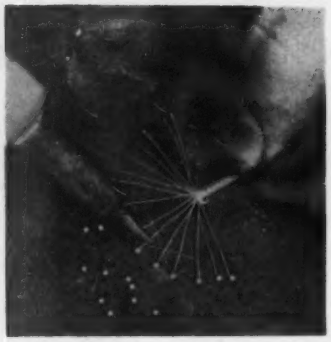
From the static characteristics, it is found that at 46 mc, 2 volts are required to change the oscillator frequency 350 kc. As can be seen from the symmetry of the display, there is little incidental a-m. The deviation of a 110-kc sine-wave modulating frequency as a function of the amplitude of the modulating signal is shown in Fig. 8. The broad-band response is still good.

Shown in the schematic of Fig. 9 is a packaged, transistorized version of the electrically tuned f-m oscillator for the 50-mc range using a 2N384 transistor. The miniature transmitter is completely enclosed in a plastic case about the size of a deck of playing cards and is powered with hearing-aid batteries.

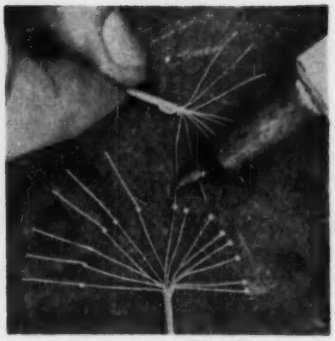
### *Panoramic Receiver*

The panoramic receiver shown in Fig. 10 sweeps between 35 and 200 mc using three front-end assemblies covering 35 to 70, 70 to 130 and 130 to 200 mc. The assemblies are plug-in units containing the electrically tunable stages (r-f, mixer and local oscillator).

The receiver uses three 20-mc synchronously tuned i-f stages followed by a crystal-diode second detector.



In making ferroelectric capacitors, leads are attached to silvered surface



Soldering iron is held about ¼ in. from dice and heat is conducted down lead

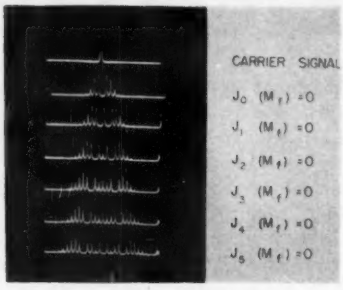



FIG. 8—Deviation of 110-kc sine-wave modulating signal is shown as a function of amplitude with 46-mc carrier and 50-volt bias

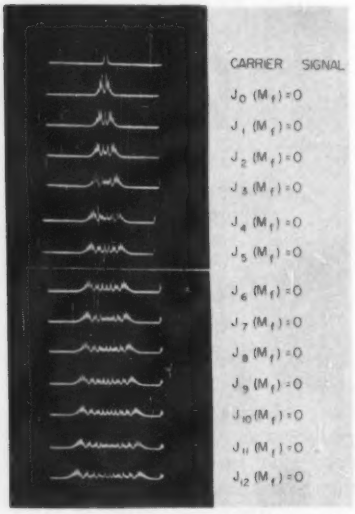



FIG. 7—Bessel function plot shows 40-kc sine-wave modulating frequency with amplitude varied to obtain indicated roots. Carrier is 46 mc and bias is 50 volts

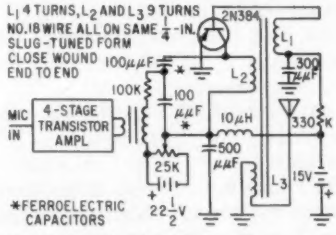



FIG. 9—Transistorized f-m oscillator operates in 50-mc range

The voltage used to tune the capacitors must be shaped to have a linear frequency change with time and hence a uniform response rate.

The panoramic display uses a 3-in. crt. The display has a variable-position notch sweep, which is used to separate and examine two signals that are very close in frequency. A passive marker circuit is also incorporated, which provides a vertical step in the base line at the frequency indicated on the calibrated dial.

The basic units of this receiver,

and the point at which it differs most widely from other receivers, are the three front-end assemblies. The principle points of difference in circuitry occur in the tuned circuits and in the method of connecting the sweep voltage.

Capacitances to ground are kept as low as possible to reduce the effect of shunt circuit capacitance on the tuning range. The sweep voltage is decoupled from the r-f loading and stray capacitance. Pairs of series-connected capacitors are used in all tank circuits. This affords less minimum capacitance and at the same time supplies a convenient d-c block for the bias voltage.

### *Afc Circuits*

A ferroelectric capacitor can be applied to an f-m tuner to obtain automatic frequency control, as shown in Fig. 11. Any change in output of the ratio detector due to local oscillator drift is fed to a d-c voltage amplifier and then applied to the ferroelectric capacitor.

The voltage-sensitive ferroelectric capacitor is in series with the temperature-compensating capacitor in the local-oscillator circuit. Thus, any change in the nominal d-c value of the bias voltage applied to the ferroelectric capacitor is reflected as a change in the capacitance of the local oscillator tank circuit. This change is sufficient to bring the resonant frequency of the local oscillator back to its initial value. The nominal d-c bias voltage is the plate voltage of the 12AX7 in Fig. 11. Since lock-in of a typical local f-m station occurs over a 4-mc range, an afc defeat switch is included in the circuit.

### *Looking Ahead*

During the course of this work, several problems were encountered that seemed worthy of further investigation.

To facilitate replacement of the tuning elements, the subminiature capacitors could be placed inside a plastic-filled transistor case. In addition, development work should be carried on to compare plastic-bead packaging to vacuum packaging. Since the tuning elements have a greater tendency to break down under conditions of high humidity, vacuum packaging would provide a convenient means of moisture proofing.

It is desirable to use titanate materials that have a small temperature coefficient of dielectric constant over a wide temperature range. In some cases, the materials do not possess this quality, and if the equipment is to be used over an extended temperature range, then methods of temperature compensation or thermostating techniques would be required to maintain receiver tuning range and sensitivity.

Since the receiver is designed to monitor communication signals, high resolution and probability-of-intercept problems were not considered important. Since a 60-cps source was available, it was used as the basic sweep rate.

If rapid sweep rates are to be employed, it will be found that there is an upper frequency limitation. This occurs because of the finite time required for changes in capacitance to take place. Tests indicate that problems become evident above sweep rates of 100 kc.

Dielectric heating may also become a problem at rapid sweep rates. This might be overcome to a large extent by keeping the dielectric volume sufficiently small.

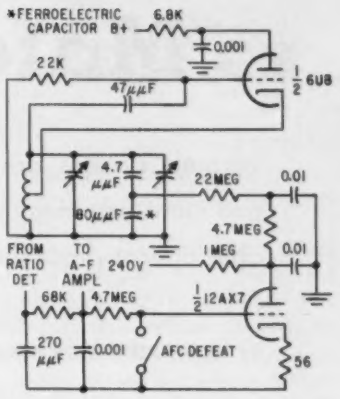



**FIG. 11—Automatic frequency control is obtained in f-m tuner by amplifying change in output from ratio detector caused by local oscillator drift and applying it to ferroelectric capacitor**

### *H-f Limitations*

It is not advisable to continue designing tunable elements for frequencies much in excess of 250 mc using presently available dielectric materials and lumped-constant design techniques. The losses become too great for satisfactory operation. However, the development of new materials and advanced design techniques will undoubtedly make possible the design of voltage-tunable elements for use at much higher frequencies.

The author wishes to acknowledge the assistance of L. W. Orr, H. Diamond and G. A. Roberts, staff members of the Electronic Defense Group. This work was sponsored by the U. S. Army Signal Corps.

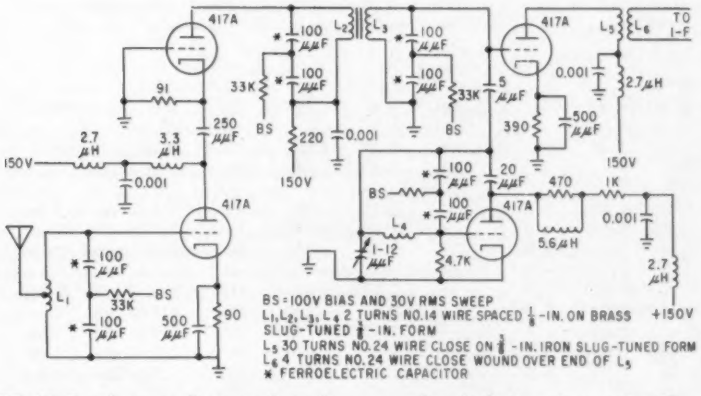



**FIG. 10—Tuned stages of panoramic receiver are packaged plug-in units covering 35 to 70, 70 to 130 and 130 to 200 mc**


### References

(1) L. W. Orr, Ferromagnetic and Ferroelectric Tuning, Technical Report No. 32, Electronic Defense Group, University of Michigan, July, 1954.

(2) M. Apstein and H. H. Wieder, Capacitor-Modulated Wide-Range F-M System, Electronics, p. 190, Oct. 1953.

# Materials for Infrared

**Infrared systems are being designed for longer and longer wavelengths and more extreme environments. Optical system designers must weigh desirable optical properties against physical characteristics and available sizes**

By **HOWARD F. HOESTEREY**, Senior Engineer, Avionics Division, Aerojet-General Corp., Azusa, Calif.

**TABLE I—Properties of Representative Infrared Transmitting Materials for Military Systems, Industrial and**

| Material | Practical Trans. Limit (microns) | % Trans. with Coating Peaked at 2.2μ | % Trans. with Coating Peaked at 4.3μ | Index of Refraction at 2.2μ | Index of Refraction at 4.3μ | Young's Modulus ($10^6$ psi) | Knoop Hardness | Density (gms/cm³) | Melting Point (°C) | Thermal Expansion Coef. ($10^{-6}$/°C) | Maximum Size |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Optical Glasses | 2.7 | 96–98 | — | 1.5–1.7 | —— | 7–10 | 300–600 | 2.3–4.6 | 1,400 | 4 to 10 | No practical limit |
| NBS glass type | | | | | | | | | | | |
| A2059 | 2.75 | 96–98 | — | 1.84 | —— | —— | —— | 5.98 | 425[a] | —— | Approx. 500–800 in.³ |
| F 158 | 4.5 | 96–98 | — | 1.78 | —— | 15.4 | —— | 4.6 | 836[a] | 8.4 | Approx. 500–800 in.³ |
| C 601 | 2.8 | 96–98 | — | 1.77 | —— | —— | —— | 4.6 | 500[a] | —— | Laboratory quantities |
| Fused quartz | 4.5 | 96 | 40 | 1.43 | 1.37 | 10.1 | 470 | 2.20 | 1,667[a] | 0.55 | 18½ in. dia × ¾ in. |
| Vycor 7905 | 3.5 | 94 | — | 1.43 | —— | 9.6 | —— | 2.18 | 1,500[a] | 0.8 | 18 in. × 18 in. × ⅜ in. |
| Arsenic Trisulfide | 12 | 96 | 96 | 2.38 | 2.35 | 2.3 | 109 | 3.20 | 196[a] | 26 | No practical limit |
| Silicon | >15 | 98 | 98 | 3.45 | 3.43 | —— | —— | 2.33 | 1,420 | 4.2 | 7¾ in. dia × 4 in. |
| Sapphire | 5.5 | 94 | 94 | 1.73 | 1.68 | 53 | 1,370 | 3.98 | 2,030 | 6.7[b] | 5½ in. dia × ⅜ in. |
| Periclase (MgO) | 6.8 | 89 | 94 | 1.71 | 1.66 | 36 | 690 | 3.59 | 2,800 | 13 | 1 in. × ½ in. |
| Germanium | >15 | 96 | 96 | 4.08 | 4.02 | 15 | —— | 5.32 | 958 | 6 | 6 in. dia × 4 in. |
| Modified selenium | 25 | 96 | 96 | 2.49 | 2.48 | —— | —— | —— | 70[a] | 32 | No practical limit |
| RIR 2 | 4.5 | 98 | 72 | 1.75 | —— | 10.2 | 576 | 4.57 | 800[a] | 8.4 | Approx. 500–800 in.³ |
| RIR 10–11–12 | 5.0 | 98 | 78 | 1.62 | —— | 15.2 | 594 | 3.07 | —— | 8.1 | Approx. 80 in.³ |
| RIR 20 | 5.5 | 98 | 80 | 1.82 | 1.79 | 12–14 | 542 | 5.18 | 760[a] | 9.6 | Approx. 80 in.³ |
| Strontium titanate | 5 | 98 | 98 | 2.23 | 2.19 | —— | 620 | 5.13 | 2,080 | 9.4 | 500 carats |
| Rutile | 6 | 96 | 96 | —— | 2.45 | —— | 880 | 4.26 | 1,825 | 9[b] | 500 carats |
| Cubic crystals | | % Transmittance (Uncoated) | | | | | | | | | |
| Lithium fluoride | 6 | 94 | | 1.38 | 1.34 | 11 | 110 | 2.6 | 870 | 36 | 6 in. dia × 4 in. |
| Calcium fluoride | 9 | 94 | | 1.42 | 1.41 | 15 | 158 | 3.18 | 1,403 | 23 | 6 in. dia × 4 in. |
| Barium fluoride | 13.5 | 84 | | —— | —— | 8 | 82 | 4.89 | 1,280 | —— | 6 in. dia × 4 in. |
| Sodium chloride | 15 | 94 | | 1.53 | 1.52 | 5.8 | 17 | 3.16 | 803 | 44 | 7.5 in. dia × 5 in. |
| Potassium chloride | 21 | 92 | | 1.47 | 1.47 | 4.3 | 8 | 1.99 | 768 | 36 | 7.5 in. dia × 5 in. |
| Silver chloride | 25 | 80 | | 2.01 | 2.00 | 2.9 | 9.5 | 5.53 | 458 | 30 | 3.75 in. dia × 6 in. |
| KRS-6 | 27 | 72 | | 2.20 | 2.19 | 3.0 | 35 | 7.19 | 424 | 51 | 5 in. dia × 3.5 in. |
| Potassium bromide | 27 | 92 | | 1.54 | 1.53 | 3.9 | 6 | 2.75 | 728 | 41 | 7.5 in. dia × 5 in. |
| Potassium iodide | 31 | 85 | | 1.63 | 1.63 | —— | —— | 3.12 | 723 | 43 | 7.5 in. dia × 5 in. |
| Cesium bromide | 40 | 82 | | 1.66 | 1.66 | 2.3 | —— | 4.44 | 636 | 48 | 7.5 in. dia × 4 in. |
| Cesium iodide | 50 | 88 | | 1.75 | 1.73 | 0.8 | —— | 4.53 | 621 | 50 | 5.5 in. dia × 4 in. |

a. Softening pt. b. Parallel to optical axis

# Windows, Domes, Lenses

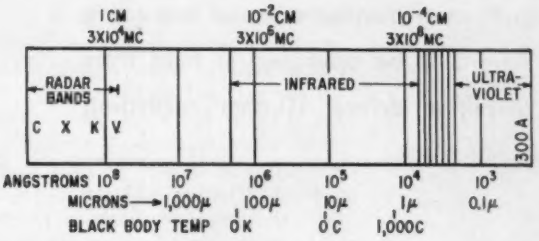



FIG. 1—Location of Infrared Spectrum

MILITARY INFRARED is coming into its own today, as radar did during World War II. Infrared (ir) is playing an increasing role in surveillance, airborne interception and missiles.

Ir's primary advantage is that it is passive, receiving its information directly from the target. All objects at temperatures above absolute zero emit electromagnetic radiations whose wavelengths are primarily in the ir spectrum (Fig. 1).

In place of an antenna, an ir system gathers information by an optical system which requires materials transparent to infrared radiations. Table 1 lists most principal types of ir transmitting materials currently available to optical designers.

The ir systems designer is concerned with optical, physical and thermal characteristics and the availability of the material in quantity. The procurement aspect is constantly changing and promising new materials are in laboratory development.

**GLASSES AND QUARTZ**—Conventional optical glasses used for photographic and visual optical infrared systems transmit ir energy in varying degrees. Most exhibit a strong absorption band at 2.8 microns and are limited, depending on thickness, to use below 2.7 microns.

Special Bureau of Standards glasses improve transmission at 2.8 microns and provide increased sensitivity to equipment with PbS detectors. Fused quartz and fused silica have helped solve the ir dome or window problem for PbS equipment.

**BEYOND 3 MICRONS**—Choice of transmitting materials is limited beyond 3 microns. Commonly employed materials include arsenic trisulfide, silicon, sapphire, germanium, calcium aluminate and strontium titanate. Other than calcium aluminate, these show little absorption and transmission is independent of the thickness.

Many of the materials have a high index of refraction. This permits spherical surfaces of less curvature for the same power, compared to conventional glasses. Monochromatic aberrations are readily minimized. Low reflectance coatings are used to overcome surface reflection losses.

Unlike materials for short wavelengths, materials transmitting longer wavelengths are limited in size and are usually expensive. For the larger aperture systems, windows or domes must be segmented from pieces. The most pressing need in ir systems development is for a satisfactory material obtainable in large sizes at an economical price.

Infrared systems development has shifted to equipment utilizing the longer wavelengths, since complete daylight capability is required. Background conditions are less severe at longer wavelengths. This has only been possible with the parallel development of miniature cryostat cooling systems.

**Laboratory Equipment**

| | Remarks and Applications |
|---|---|
| | Useful in the near ir region as objectives, windows and domes |
| | Improved near ir transmission over conventional optical glasses from 2.5 to 2.8 μ. Applicable for objectives, field lenses. F158, also suitable for windows or domes<br>Excellent physical characteristics. Infrasil is similar |
| | Excellent window or dome for near ir |
| | All elements when environment not severe |
| | Desirable long wave material, transmission reduced at 350°C, practically opaque at 500°C<br>Desirable physical properties, good transmission at 500°C |
| | Excellent at high temperature, potential dome or window material<br>Filter for solar energy, useful in objectives and field lenses |
| | Low melting, limited use in all elements |
| | Good general purpose optical material for restricted spectral band. Similar to F158<br>Calcium aluminate, attacked by moisture |
| | Laboratory state at present and quite expensive<br>Field lens uses for immersed detectors<br>Severely anisotropic. Potential field lens usage |
| | Principal usage in laboratory equipments under controlled environment. The materials are in general soft, difficult to polish, hygroscopic and have high thermal expansion. Except for calcium fluoride, have little practical military value<br>Recent developments in hot pressing techniques have produced some promising long wavelength transmitting materials of barium fluoride and magnesium floride. $MgF_2$ appears especially suited for dome applications |
| | KRS-5 is similar, usable to 38μ, used in German military ir systems in World War II, thallium bromide-thallium-iodide |

# Transistorizing 16-Mm

**Use of 12-v d-c to 110-v a-c power supply and transistor sound recording amplifier permits 16-mm sound-on-film camera to be operated in field from 12-v nickel-cadmium cells. Transistor amplifier drives 10-ohm recording galvanometer for variable-area optical sound track**

By **EDWARD M. TINK,** Assistant Chief Engineer, WLAC-TV Inc., Nashville, Tenn.

SIXTEEN-MILLIMETER cameras with optical sound recording have long been used in television broadcasting for on-the-spot news coverage of both picture and sound. One camera, having a film capacity of 100 ft, for 2¾ min, is housed in a relatively large portable case with a weight of 45 lb or in two smaller cases weighing a total of 60 lb. Though the recording amplifier has a self-contained battery supply, the camera drive motor requires an external source of 115-v 60-cps power.

A smaller and more desirable system results if a miniature transistor amplifier, mounted directly on the camera, is substituted for the vacuum-tube amplifier and a portable 115-v power pack is used to supply the motor. A commercially available power pack employing two 6-v nickel-cadmium cells driving a transformer and vibrator supplies the 115 v. The 12 v also furnishes collector voltage to the transistor amplifier and current to the sound exposure lamp in the camera, thus eliminating all additional batteries.

The variable-area recording galvanometer in the camera has an impedance of 10 ohms at 400 cps and is designed to be driven from a 50-ohm source through a 40-ohm series isolating resistor; 100-percent modulation is represented by an output of 1.6-v rms (52 mw) across the 50-ohm output. The equalization required for speech recording results in a frequency response 12 to 14 db down at 100 cps, rising to +3 db at 3 kc and returning to 0 db at 5 kc.

### Amplifier Design

A class-A push-pull output circuit was decided on for low distortion. Due to its greater power sensitivity, the common-emitter configuration was used as can be seen in the circuit of Fig. 1.

A thorough search of available miniature transistor output transformers indicated that there were practically none designed to work into a 50-ohm load. It was also observed that the transformers had efficiencies varying from 15 to 50 percent. For these reasons a ferrite-core transformer having an efficiency greater than 70 percent was designed for this particular application. The design was simplified by the fact that the low-frequency requirements of the amplifier are not too severe.

One of the greatest objections to the use of the ferrite core is that it saturates quite easily and therefore the effective d-c current through the primary winding must be kept low. It was at first thought that the requirement of a low value of d-c unbalance in primary current would require the use of matched output transistors. This, however, was not a problem since all of the output transistors which were used at various times (2N43, 2N44, and 2N188A) were matched within less than 1 ma.

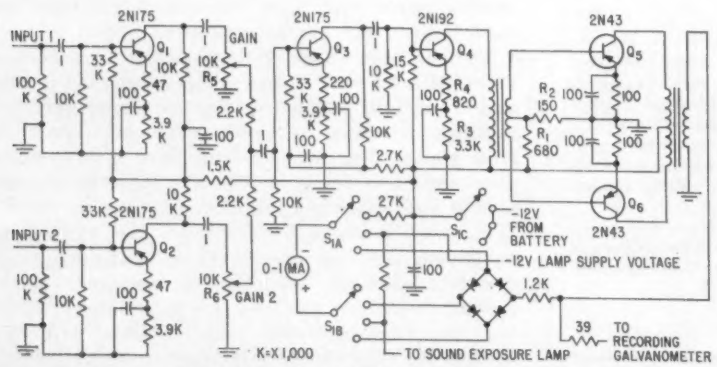



FIG. 1—Dual-input amplifier for Auricon CM-72A drives recording galvanometer

### Collector Dissipation

Due to the low collector-to-emitter voltage available (approximately 10 v) it was necessary to operate the 2N43 collectors near their maximum dissipation rating to obtain the required output power with low distortion. The allowable transistor power dissipation is dependent upon the maximum ambient temperature which will be encountered and is given by the expression $P = (85-T_A)/K$ where $T_A$ is the maximum ambient and $K$ is the thermal resistance in deg C per mw.

# Tv Remote Film Camera

It was felt that the amplifier might be expected to operate in ambient temperatures as high as 110 F (43 C). Since the thermal resistance for the 2N43 is 0.2 C per mw (with a heat sink whose minimum area is 0.95 sq in.), the dissipation must be limited to 210 mw per transistor. This limits the collector current to a maximum of 21 ma with a collector-to-emitter voltage of 10 v.

The heat sink consists of a 1-in. sleeve of copper tubing. Good thermal contact can be maintained between the transistor body and the heat sink by removing the paint from the transistor body.

With a d-c collector-to-emitter voltage of 10 v, the maximum peak-to-peak excursion of voltage across the transformer is slightly less than 40 v. With a turns ratio of approximately 5.5 to 1, the maximum voltage across the 50-ohm secondary will be approximately 7 v. peak-to-peak. Thus the maximum power output before clipping occurs will be in the vicinity of 125 mw.

### Bias Stabilization

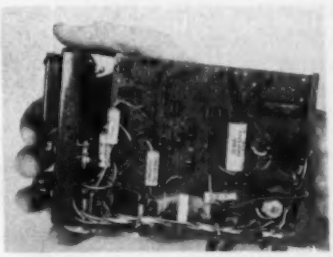
The 100-ohm resistors to ground, in series with the emitter-to-base junction of the output transistors, help prevent thermal runaway. In addition, base voltage stabilization is obtained by the network consisting of $R_1$ and $R_2$. As this stabilization was adequate, no nonlinear stabilizing units were employed.

The driver stage employs a 2N192 transformer coupled to the output circuit. The relatively large value of $R_3$ in the emitter circuit, along with the base voltage stabilization, again contribute to excellent temperature stability. A smaller unbypassed resistor, $R_4$, also placed in series with the emitter provides approximately 16 db of gain reduction and results in excellent overload characteristics, with uniform gain and frequency response with variations in transistor parameters.

### Input Stages

The two input stages and the following stage all employ 2N175 low-noise transistors. Good temperature stability is obtained by the methods used in the driver stage and in addition d-c collector-to-base feedback is employed. The unbypassed emitter resistors result in a gain reduction of 12 db in $Q_3$ and 5 db in $Q_1$ and $Q_2$.

Transistor amplifier is mounted on camera



Inside view of recording amplifier

There is a maximum interaction of 5 db between gain controls $R_5$ and $R_6$ under the worst possible condition—feeding a signal in channel 1 and changing gain control 2 from minimum to maximum. Measurements indicate that no frequency discrimination occurs at any combination of settings of the gain controls.

A miniature meter included in the circuit measures 12 volts d-c from the batteries, sound-exposure-lamp current and audio output level. The shunts and multipliers are so calculated that the proper values of voltage and current (12v, 140 ma and 100-percent modulation) in all three meter positions results in exactly half-scale deflection.

### Amplifier Performance

A signal-to-noise ratio of 56 db was measured in both channels. Since each channel has a gain of approximately 81 db, this results in an equivalent noise input of 137 db. The harmonic distortion, measured at 1,000 cps across the 50-ohm secondary winding, was 1.9 percent with an output level of 1.6 v. rms (100-percent modulation).

The measured low-frequency response was down 14 db at 250 cps, but listening tests indicated that this slight deficiency in low-frequency response was not at all objectionable. As the low-frequency response fell, the distortion rose to a value of 3.2 percent at 250 cps. As the frequency increased beyond 1,000 cps, the distortion remained equal to or less than the value for 1,000 cps. High-frequency response was flat within ±1 db to 9,000 cps, which is beyond the upper limit of 16-mm sound-on-film recording capability.

It was necessary to make some wiring changes in the Dormitzer DY-1012 power pack to obtain the proper polarity for the 12-v d-c output. One of the parallel pilot lamps in the battery charging circuit was eliminated to bring the charging current down to 450 ma, which is within the rating of the new rectifier. Finally, a potentiometer was added to control the sound-exposure-lamp current. A large amount of filtering was required to remove the vibrator hash from the battery leads. Although this modified camera has been in use only a short time by the news department at WLAC-TV, early results indicate that its operation is reliable and that good quality sound-on-film recordings are readily obtained by personnel not particularly accustomed to operating electronic gear.

The author expresses his appreciation to Chief Engineer R. L. Hucaby and to the station engineers for their assistance.

# Differential Amplifier

**Analysis of common-emitter circuit points to basic causes of drift in a transistor amplifier for d-c signals. Differential amplifier incorporates temperature-compensating element with positive coefficient**

By **W. T. MATZEN** and **J. R. BIARD**, Texas Instruments Inc., Dallas, Texas

SUCCESSFUL DESIGN of a transistorized amplifier with adequate d-c stability requires an understanding of the basic causes of drift in transistors and then the development of circuits to minimize these effects.

Drift is specified in terms of the change of input voltage required to maintain constant output when circuit parameters vary. The major sources of drift in a transistor amplifier are shifts of the base-emitter voltage, $V_{be}$; the d-c current transfer ratio $\alpha$; and collector current, $I_{co}$. The three parameters are temperature dependent and may also vary with time.

Drift due to variation of transistor parameters may be analyzed by reference to the common-emitter amplifier, Fig. 1. In this circuit, it is assumed that the two transistors have equal parameters but that drift sources may vary with time and temperature. Quantity $R_b$ is the sum of the base resistance, $r_b$ and the resistance of the source. Resistance $R_e$ includes the internal emitter resistance $r_e$ and the external resistance in series with the emitter.

### *Drift Analysis*

The change of differential input voltage required to maintain the collector currents constant when the parameters of the transistor vary is:

$$\Delta V_1 - \Delta V_2 = -(\Delta V_{be1} - \Delta V_{be2}) + [(R_b + R_e)(\Delta I_{co1} - \Delta I_{co2})/\alpha] + (R_b + R_e)(\Delta I_{b1} - \Delta I_{b2})$$

in which $\Delta V_{be}$ and $\Delta I_{co}$ are the changes of $V_{be}$ and $I_{co}$ respectively and $\Delta I_b$ is the change of the base current necessary to maintain the collector current constant when $\alpha$ changes.

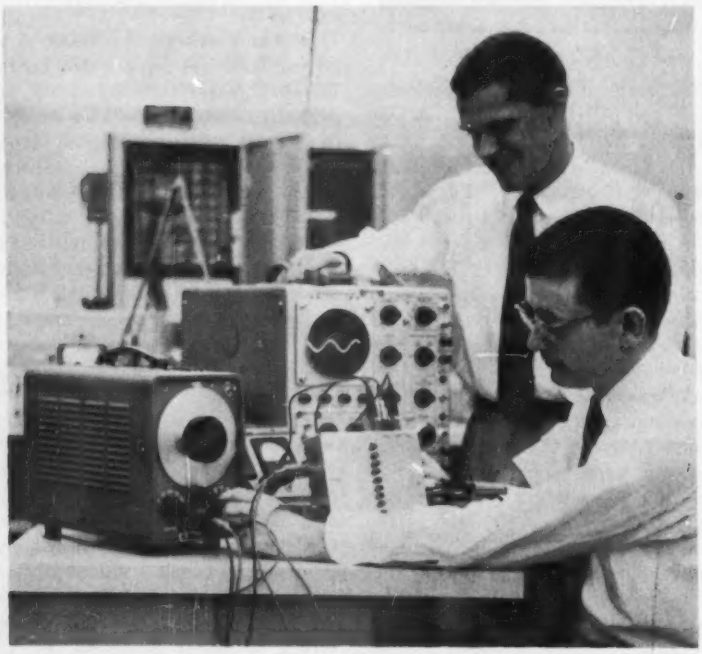
The base-to-emitter voltage, $V_{be}$, decreases almost linearly with temperature at a rate of 2.6 mv/deg C in silicon transistors; and 2.3 mv/deg C in germanium transistors.

These coefficients vary only about 10 deg for transistors of a given type.

The change of $I_b$ necessary to maintain the collector current constant with time or temperature is less at low quiescent values of $I_{co}$.

Drift due to $V_{be}$ or $\alpha$ is of the same order of magnitude in silicon and germanium transistors. However, silicon transistors provide better overall stability in d-c amplifiers because of their inherently low $I_{co}$. Since $I_{co}$ in silicon transistors is determined primarily by leakage, there is some variation between the temperature coefficients of different transistors. The change with either time or temperature will, in general, be less for a unit which has a low value of $I_{co}$ at the operating temperature. Leakage effects are also reduced by operation at low collector voltages.

When low resistances are maintained in series with the base and emitter leads, the drift in a silicon transistor amplifier, properly biased and operating at tempera-



**Engineers demonstrate the low-drift d-c differential amplifier. Output of amplifier is visable on the oscilloscope screen**

# Features D-C Stability

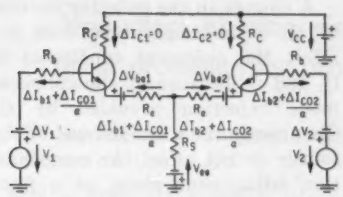


FIG. 1—Common-emitter amplifier configuration, used to pinpoint basic causes of drift sources

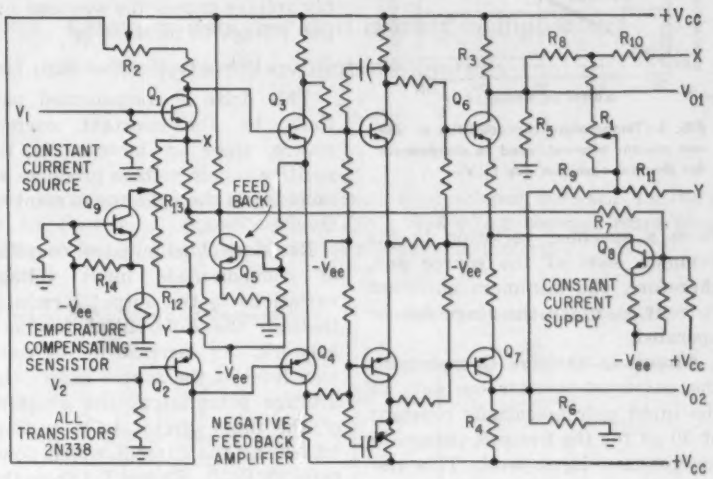



FIG. 2—Transistor d-c differential amplifier circuit has drift characteristics superior to those of its vacuum-tube counterpart when used with low-impedance sources such a strain gages and thermocouples

tures below 80 C, is due primarily to thermal changes of $V_{be}$. Since $V_{be}$ has a predictable temperature characteristic and is stable with time, its thermal effect is reduced appreciably by the differential connection.

Extremely low drift is possible in the differential amplifier when the stage is designed for proper bias levels and transistors are selected for desirable characteristics under the required conditions of operation.

Gain of a differential stage, such as that shown in Fig. 1, to the differential signal $V_1 - V_2$ is approximately the same as the low-frequency a-c gain of the amplifier, considering the center connection of the two emitter resistors to be grounded.

The emitter currents for zero differential input may be controlled independently of the differential gain by choice of $R_e$. When $R_e$ is a large resistance, or a transistor constant current source, the emitter currents are essentially independent of the average input voltage, $(V_1 + V_2)/2$.

### Amplifier Design

The circuit of Fig. 2 is designed for maximum open-loop amplification of the differential signal. Series-shunt negative feedback provides a high input impedance and low output impedance. The closed-loop gain is determined by the differential feedback network and can be adjusted by varying $R_1$. Local shunt feedback in the third stage shapes the frequency response and prevents oscillation under closed-loop conditions.

Since all of the transistors are *npn*, the voltage level is increased at the collector of each stage. Voltage divider networks in the collector circuits of the second and third stages drop the average output voltage to the desired level. Resistor $R_3$ provides zero adjustment for the differential output, or a level control for either of the single-ended terminals. No provision is made for adjusting the average output voltage.

### Input Circuit

The d-c stability of the amplifier is determined primarily by the input stage, since the equivalent input drift due to any subsequent stage is reduced by the preceeding gain. This stage is therefore operated at bias conditions which produce minimum drift. Transistors with the best d-c characteristics are used for the input pair.

The optimum collector current for the first stage was selected to be fifty microamps. Operation at lower levels would deteriorate the gain due to a decrease in $\alpha$ and an increase in the emitter diode resistance, $r_e$, thus increasing the drift contribution of the second stage.

### Thermal Matching

Because of the linearity of the $V_{be}$ temperature characteristic, it is possible to match $V_{be}$ thermal coefficients for the input pair within 60 $\mu$v/deg C by measuring $V_{be}$ at two widely different temperatures. The magnitudes of $V_{be}$ are also matched to reduce the required range of zero adjustment.

Temperature coefficients for $I_{co}$ and $\alpha$ are not considered sufficiently uniform to warrant matching. Effects of $I_{co}$ are minimized by selecting units with low $I_{co}$ at the operating temperature.

The amplifier of Fig. 2 responds to a differential signal of 25 $\mu$v superimposed on a common level which varies from zero to five volts. An input circuit, similar to that of Fig. 1, with a high value of $R_e$ provides sufficient common-mode rejection to operate under these conditions. However, when series feedback is applied to the input, the feedback resistors shunt $R_e$ and reduce the common mode rejection factor. The value of the feedback resistors determines the change of collector current which results

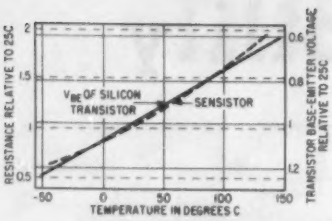



**FIG. 3—Temperature characteristics of silicon resistor element, used to compensate for thermal variation due to $V_{be}$.**

from a specified variation in the common level of the source and, therefore, the minimum quiescent current at which the stage can be operated.

Circuit $Q_1$ through $Q_5$ maintains the quiescent emitter currents of the input pair essentially constant at 50 $\mu$a for the five-volt change in the common input level. This circuit acts as a negative feedback amplifier in which the common level of the source is the input and the potential of the emitters of $Q_3$ and $Q_4$ is the output.

Output is fed back to the emitters of $Q_1$ and $Q_2$ by the feedback transistor $Q_5$ in such a direction as to oppose a change of input current. Amplified feedback provides adequate common-mode rejection by maintaining the closed-loop gain of the common-level amplifier at less than unity. Small common level changes which occur at the collectors of $Q_1$ and $Q_2$ are further rejected by the common mode rejection of the second, third and fourth stages.

### Output Circuit

Output impedance for single-ended loads is determined by the collector supply networks in the final stage. Since the collectors of $Q_6$ and $Q_7$ are effectively connected by the low differential output impedance, the output impedance from either terminal to ground is approximately the parallel combination of $R_{13}$, $R_{14}$, $R_{15}$ and $R_{16}$.

When a single-ended output is used, drift in the average level of the output must be eliminated as well as differential drifts. The average voltage of the output terminals is made independent of the emitter potentials of $Q_6$ and $Q_7$ by $Q_8$ which acts as a constant-current supply.

Variations of the supply voltage present another source of drift in the single-ended output circuit. An increase, $\Delta V_{cc}$, in the positive supply voltage causes the average output voltage to increase by

$$\Delta V_o = \Delta V_{cc} [R_5/(R_3 + R_5)]$$

This drift is compensated partially by the constant current source, since an increase in the positive supply voltage produces an increase in the collector current of $Q_8$.

Resistor $R_7$ eliminates coupling of common-mode input voltage variations to the output terminals through the differential feedback network. An increase in the common level of the source causes the average potential at the emitters of the input circuit to rise, thus increasing the current which flows through $R_8$, $R_9$, $R_{10}$ and $R_{11}$, from the emitters of the input stage to the output collectors. The average potential of the output terminals can remain constant only if the collector currents of $Q_6$ and $Q_7$ increase such that the currents in the collector supply networks of the final stage do not change.

The increase in the average emitter potential of the first stage causes the base of $Q_8$ to increase due to the connection through $R_7$. Since $Q_8$ determines the average collector current of the final stage, collector currents of $Q_6$ and $Q_7$ are also increased. Resistor $R_7$ may be adjusted such that the average output level is not affected by common-mode variations of the source.

### Thermal Compensator

Overall drift of the amplifier is compensated by a special silicon resistor, $R_{12}$, which has a positive temperature coefficient. The Sensistor silicon resistor compensates for thermal variation resulting from $V_{be}$, which is the primary cause of amplifier drift. Temperature characteristics of this element are shown in Fig. 3.

A variation of $R_{12}$ with temperature changes the collector current of $Q_9$ and the current in potentiometer $R_{13}$. The amount of this change is determined by the bias current which is supplied to the silicon resistor through $R_{14}$. When $R_{13}$ is moved from its center position, a temperature-dependent potential is produced between the emitters of $Q_1$ and $Q_2$ which may be adjusted for the desired compensation.

A change in the collector current of $Q_9$ with temperature does not affect the quiescent conditions of $Q_1$ and $Q_2$ because of the common-mode rejection provided by $Q_5$. Changes in the average level of the source do not affect the compensation adjustment since, at a fixed temperature, $Q_9$ is a constant-current source.

### Test Results

The amplifier has a voltage gain for a single-ended output which is continuously variable from 100 to 500 and a frequency response flat within one percent to 1,000 cps. When used with low impedance sources such as strain gages and thermocouples it has drift characteristics superior to those of its electron-tube counterpart.

The differential input impedance is in excess of 140,000 ohms. The output impedance to a single-ended signal is less than 1,000 ohms and to a differential signal is less than 50 ohms. The common mode rejection factor is greater than 50,000 to 1.

Drift was evaluated over a 12-hour period after initial warmup of 45 minutes. The equivalent input drift is less than 60 $\mu$v from 70 C to 80 C. For critical drift applications, the amplifier should be operated under closely controlled temperature conditions.

The input transistor pair and the silicon resistor should be mounted in a common heat sink of high thermal capacity. This procedure reduces transient drifts due to different thermal time constants. The minimum drift attainable is limited by the stability of the transistor coefficients with time, the accuracy of adjusting the temperature-compensation network and the degree to which the temperature characteristic of the compensation network matches the drift characteristic of the amplifier.

Size, low-power requirements and low drift make the amplifier desirable for military telemetering systems. Because of its versatility, many other applications will be apparent for industrial and laboratory instrumentation.

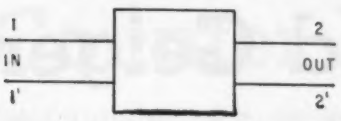
# Hall-Effect Devices

## Hall-effect isolator, circulator, spectrum analyzer and analog multiplier are most promising for practical uses with currently available materials

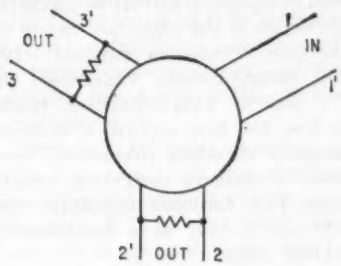
**By Ronald K. Jurgen,** Associate Editor

WHEN A STRIP of metal is placed with its plane perpendicular to a magnetic field and an electric current flows longitudinally through the strip, a potential difference is developed between its two opposite edges. This Hall effect becomes more pronounced with semiconductor materials.

**Gyrator and Isolator**

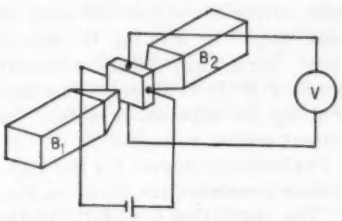



**Circulator**



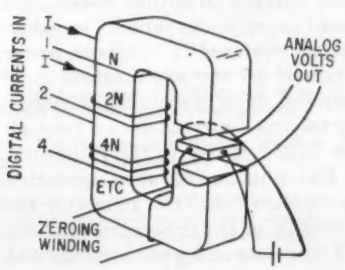

Load resistances must be of proper values for device to circulate. May be used with parallel resistances

**Electrical Compass**

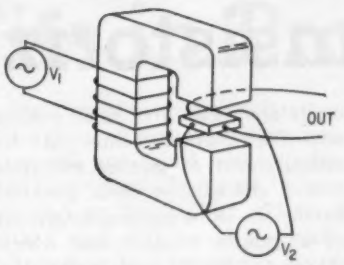



Magnetic bars $B_1$ and $B_2$ concentrate earth's magnetic field at sample. Bars are rotated for null reading

**Digital-to-Analog Encoder**

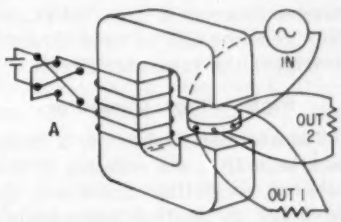



**Product Modulator and Demodulator**



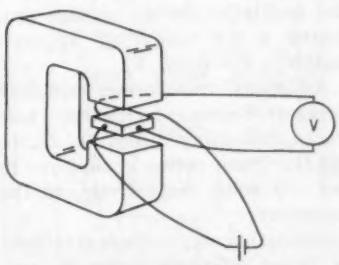

Also circuit for analog multiplier and frequency spectrum analyzer. Output is proportional to product of $V_1$ and $V_2$

**Switch**



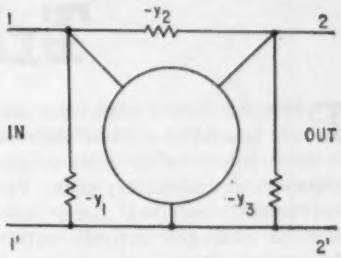

Position of switch $A$ determines whether input is transmitted to output No. 1 or 2

**Magnetic Field Meter, Transducer**



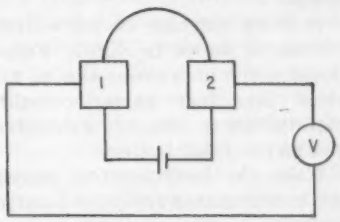

When used as a transducer (for microphone or strain gage), sample moves in and out of magnetic increasing or decreasing voltmeter reading respectively

**Negative-Resistance Amplifier**



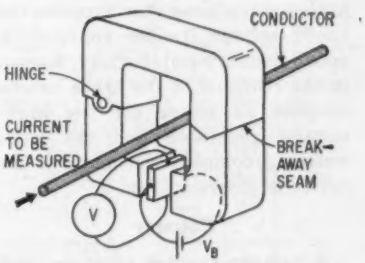

For amplifier to isolate, $y_1$, $y_2$ and $y_3$ must have precise values

**Magnetic-Field-Variation Meter**



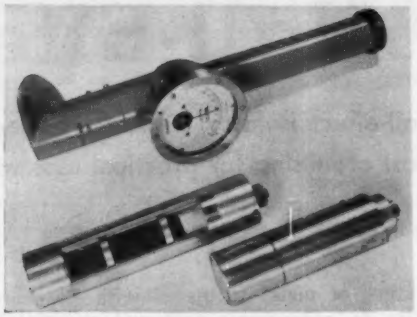

If magnetic field is different in two samples, voltmeter reads; if not, outputs cancel

**Ammeter**




Some type of box holds sample and magnet pieces together. Device becomes wattmeter if voltage across conductors is used in place of $V_B$

Direct-indicating logarithmic scale on meter of transistorized Geiger counter eliminates reading error resulting from incorrect positioning of range switch



Disassembled probe handle showing case and meter (top), high-voltage generator and ratemeter circuit board (bottom, left) and battery housing (right)

# Transistorized Geiger

PORTABLE GEIGER COUNTERS usually consist of a probe-mounted detector connected by cable to separate circuit and battery packs. The instrument described here, however, is packaged entirely within the probe. This compactness is achieved through use of transistorized circuits which provide additional advantages of extended battery life and increased reliability. Complete unit weighs less than two pounds.

A block diagram of the Geiger counter is shown in Fig. 1. Functionally, the instrument can be divided into four parts: counter, high-voltage generator, ratemeter and mercury-cell battery.

When the instrument is placed in a contaminated area, the counter produces a series of output pulses at a rate proportional to the radiation intensity present. Output pulses from the counter are then converted by the ratemeter into a meter indication which is proportional to the counter pulse rate. The high-voltage generator supplies the anode voltage for the counter. A small mercury-cell battery housed in the rear end of the probe handle supplies all power for the high-voltage generator and the ratemeter. A complete schematic of the device is shown in Fig. 2.

### Counter

A halogen counter must be used which will operate at a relatively low anode potential of +480 volts. The three counter types most generally applicable are: small gamma sensitive counters intended for measurement of gamma radiation fields; end-window beta counters having the same gamma sensitivity as a gamma counter and which, therefore, can be used in the dual capacity of a beta-gamma counter; and thin-walled beta sensitive counters which can be used for detection of small intensity radiation from beta- or gamma- active materials. Since the output from these halogen counters is large, the pulses they generate can be used directly to trigger the ratemeter circuit.

### High-Voltage Generator

Transformer $T_1$ provides a feedback path from the collector to the base of oscillating transistor $Q_1$ necessary to produce self-sustaining oscillations. The oscillations produce a 10-kc sine wave which is stepped up to 160 volts peak-to-peak by winding $W_1$ on $T_1$. A Cockroft-Walton multiplier network containing $D_1$, $D_2$, $D_3$, $D_4$, $D_5$ and $D_6$ rectifies and multiplies the a-c voltage producing a d-c output of approximately +480 volts.

Additional transformer taps feed Cockroft-Walton multiplier networks containing diodes $D_7$, $D_8$, $D_9$ and $D_{10}$. These networks supply −19 and −9 volts, respectively, to the ratemeter.

Oscillation amplitude is stabilized by Zener reference diode $D_{11}$ connected between the −19-volt line and the biasing point for the base of transistor $Q_1$. During normal operation, current flowing in $R_1$ biases the base of $Q_1$ in a forward direction causing the circuit to oscillate. However, if the amplitude tends to increase beyond the nominal −19-volt point, reverse breakdown of $D_{11}$ occurs. This condition tends to bias the base circuit of $Q_1$ in a negative direction preventing further increase in oscillation amplitude. This feedback maintains the −19-volt supply at a consistently correct value.

Physical variations introduced during the manufacture of 1N204 diodes used for the $D_{11}$ function produce an operating voltage spread of 19 ±1.9 volts. To permit accurate setting of the 160-volt peak-to-peak output at winding $W_1$ despite these variations, small auxiliary winding $W_2$ is used which has taps that can be adjusted to obtain the correct output voltage.

Performance curves for the high-voltage generator are shown in Fig. 3. The regulation curve illustrates voltage variations at the junction of $D_6$ and $C_1$ under different loading conditions. The efficiency curve shows the relationship of input battery current to output power as a function of load current. In calculating efficiency, a constant power drain of 0.5 mw was assumed to be imposed upon the oscillator circuit by the small current drawn through the −19-volt line in the ratemeter.

Examination of the regulation curve shows that the generator exhibits an output impedance of about 1.3 megohms at higher currents and

**Ratemeter circuit converts output of halogen-type counter directly into meter indication corresponding to radiation intensity. Counter triggers two-transistor switch placing low-impedance load across conventional dual-output diode pump. Two halves of pump current are summed in metering circuit**

By **F. S. GOULDING,** Atomic Energy of Canada, Ltd., Chalk River, Ontario, Canada

# Counter Fits in Probe

that its impedance rises slightly at lower currents. Generator impedance is primarily made up of the output impedance of the Cockroft-Walton multiplier, the resistance of the transformer windings and the reflected impedance of the Zener regulator circuit.

Converter efficiency reaches a fairly high value of 60 percent when the output is loaded by currents on the order of 20 $\mu$a. At lower currents, which are more applicable to this particular instrument, the efficiency is low. Power is taken by the stabilizing circuit itself; for example, the Zener diode usually passes current on the order of 100 $\mu$a and, therefore, consumes approximately 2 mw. Remainder of power losses when the load current is small are consumed in transistor collector dissipation and in the transformer.

Stability of the output voltage as a function of battery voltage was measured and found adequate for this instrument. A change in battery voltage from 6.75 to 5.75 volts with a load of 3 $\mu$a on the high-voltage generator produced a 2-volt change in output.

### *Ratemeter*

The ratemeter circuit consists of two parts; a transistor switch, and a diode pump and metering circuit. Transistors $Q_2$ and $Q_3$ together with their associated components constitute the switch. Counter pulses fed through coupling capacitor $C_2$ trigger the switch transmitting the pulses to a diode pump made up of diodes $D_{12}$ and $D_{13}$, capacitors $C_3$ and $C_4$, and resistors $R_2$ and $R_3$. Output current from the pump is then converted to a dial indication by a metering circuit consisting of meter $M_1$, resistors $R_4$, $R_5$ and $R_6$, and capacitors $C_5$ and $C_6$.

When actuated, the pulse operated switch presents a low impedance output to any load connected between the collector of $Q_3$ and the base of $Q_2$. In this case, the load consists of capacitor $C_7$ and the diode pump.

Under steady state conditions, the switch circuit potentials are established in the following manner. The network consisting of potentiometer $R_7$, and resistors $R_8$ and $R_9$ produces 3.3 volts at the anode of diode $D_{14}$. Neglecting the small voltage drop across the diode, a current drain of approximately 100 $\mu$a flows in resistor $R_{10}$ which clamps the cathode of $D_{14}$ at 3.3 volts. The collector junction of $Q_2$ leaks a small amount of current which, in general, will be appreciably smaller than 10 $\mu$a at room

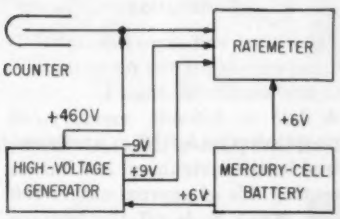



**FIG. 1—Counter produces pulses whose rate of occurrence is proportional to radiation intensity of contaminated area**

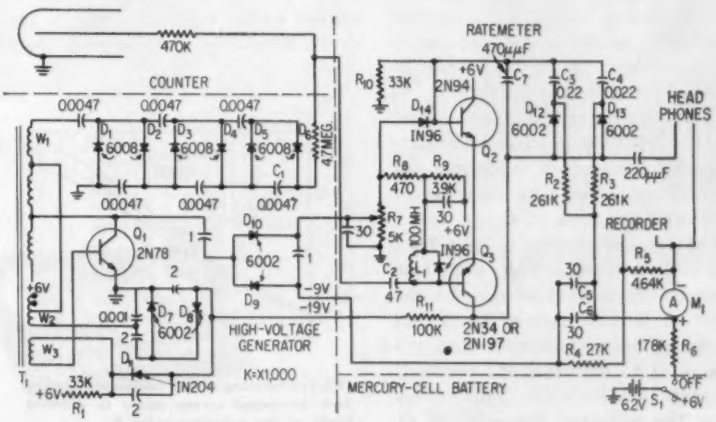



**FIG. 2—Geiger counter circuits. Winding $W_3$ provides approximately correct feedback driving voltage to transistor $Q_1$ to maintain output d-c level constant. High oscillator frequency permits good smoothing of rectifier output using small capacitors. Crystal-type headphones are used**

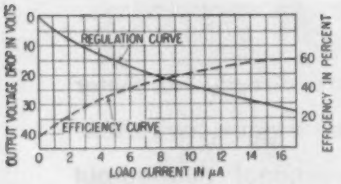



**FIG. 3—Regulation and efficiency curves for high-voltage generator**

temperature, but will double for every 10 C rise. Since this instrument is intended to operate up to 55 C, leakage currents in $Q_2$ as high as 100 μa can develop. Although the leakage current tends to raise the base potential of $Q_2$, the current flowing in $R_{10}$ holds the base voltage to 3.3 volts.

Resistor chain $R_7$, $R_8$ and $R_9$ holds the base of $Q_2$ at approximately 3.6 volts. Negligible d-c resistance is introduced by coil $L_1$.

Since the base of $Q_2$ is positive relative to the base of $Q_1$, the emitters of the two transistors are reversed biased. Under this condition, no current can flow through the transistors except for the small leakage current at the junctions. Therefore, the magnitude of steady-state collector voltage at $Q_2$ is determined only by the amount of leakage current flowing in resistor $R_{11}$. Since leakage current can rise to 100 μa at 55 C, the steady-state voltage of the collector will lie between −19 and −9 volts.

When radiation is sensed, a negative counter pulse is produced which is applied through $C_2$ to the base of $Q_3$ causing the switch to conduct. This condition tends to lower the emitter potential of $Q_3$ which is driving the emitter of $Q_2$. Also, the collector potential of $Q_3$ becomes positive going which, when applied through $C_7$ to the base of $Q_2$, causes $Q_2$ to conduct. Then $Q_2$, acting as an emitter follower, drives $Q_3$ to produce more current. This regenerative feedback process eventually triggers the switch, shorting out the load connected between collector of $Q_3$ and the base of $Q_2$.

The trigger circuit relaxes back into its nonconducting condition when the capacitors across the collector of $Q_3$ and base of $Q_2$ do not discharge enough current into the base of $Q_2$ to maintain the conducting state of the circuit. This occurs when the collector potential of $Q_3$ rises to the same level as that at the base of $Q_2$. Length of conduction is determined by the time constants of the components in the collector circuit.

### Diode Pump

To facilitate discussion, the half of the diode pump circuit containing $C_3$, $D_{12}$ and $R_2$ will be considered first. When no counts are entering the system, the meter reads zero and the metering circuit applies −9 volts to $R_2$. Under steady-state conditions, the anode of $D_{12}$ is connected to the collector of transistor $Q_3$ whose voltage will vary between −19 and −9 volts as described previously. Since the cathode of $D_{12}$ is connected to −9 volts through $R_2$, the diode is reversed biased and passes practically no current.

After the circuit has been in the steady-state condition sufficiently long, capacitor $C_3$ becomes charged to the potential which exists between the base of $Q_2$ and −9 volts. At this time, no current will flow in $R_2$. When an input pulse triggers the transistor switching circuit, the collector of $Q_3$ rises rapidly to the base potential of $Q_2$. This potential is applied to $C_3$ through $D_{12}$ causing $C_3$ to discharge through $R_2$ and the metering circuit. When the switching transistors become nonconducting, $C_3$ again recharges through $R_2$. The quantity of current flowing in the metering circuit as $C_3$ discharges is determined by the voltage swing across $C_3$.

If the pulses are applied at a slow rate, the meter current will be proportional to the count rate. However, if the count rate is fast, $C_3$ cannot completely recharge in the short time interval between successive counter pulses. This condition causes the amount of charge per pulse to fall as the count rate increases. Therefore, high count rates cause a uniform potential to be maintained across $R_2$ giving a constant current through the metering circuit.

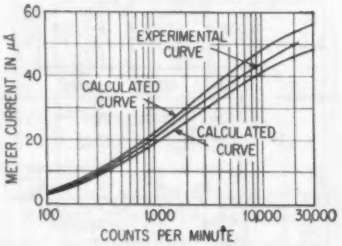



**FIG. 4—Metering circuit calibration curves. Two calculated curves apply to extreme limits of the adjustment for $R_2$**

The other half of the diode pump circuit contains $C_4$, $D_{13}$ and $R_3$, and operates in a similar manner. In this case, however, the value of $C_4$ is ten times smaller than that of $C_3$. This feature permits the counting rates at which nonlinearities appear, in the curves representing meter current as a function of counting rate, to be higher by a factor of ten.

Total current obtained from the two halves of the diode pump are summed by the metering current. This technique permits an approximate logarithmic indication of count rate to be obtained over two decades. Although the voltage developed across the metering circuit modifies this relationship slightly, it does not alter the basic results.

Since the counts entering the ratemeter appear randomly, the meter reading fluctuates. A time constant of approximately two seconds is used to average out the fluctuations at low counting rates. This time interval represents a compromise between requirements for reducing statistical fluctuations in the readings and for obtaining adequate speed of response in detecting small intensity radiations. Component values of tank capacitors $C_5$ and $C_6$ and resistors $R_4$ and $R_5$ determine the time constant of the circuit.

### Calibration

Calculated and experimental calibration curves for the metering circuit are shown in Fig. 4.

A 6.25 ± 0.5-volt, mercury-cell battery supplies all the power required by the instrument and has an operating life of approximately 100 hours. When $S_1$ is off the battery voltage is monitored by the metering circuit containing $R_6$, the meter and additional small components. This technique provides a battery check and, since the current drain from the battery under these circumstances is only 24μa, battery life is not impaired.

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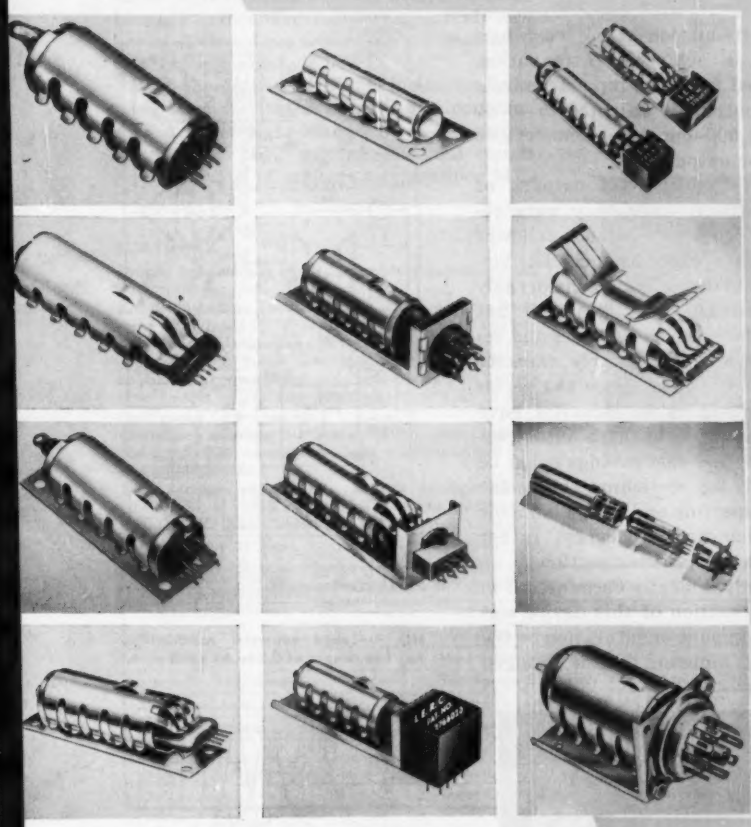

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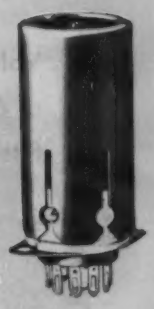

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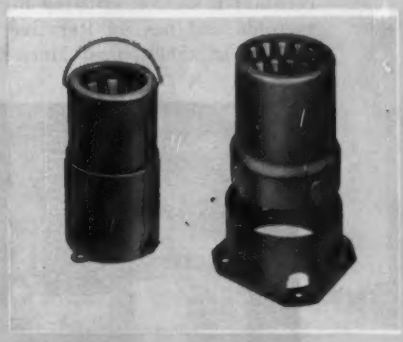
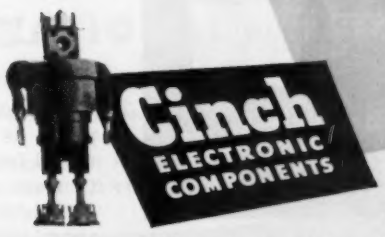


OCTAL and POWER SHIELDS

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# Tuned Voltmeter Reads Harmonic Amplitude

**Voltmeter circuit has four bandpass filters tuned to the first four harmonics of 60-cps power-line frequency and a vtvm to measure the voltage at each filter output. Outputs allow continuous monitoring of each harmonic voltage**

By **R. S. BROWN,** Midwest Research Institute, Kansas City, Mo.

POWER-SYSTEMS analysis may require a voltmeter that measures the amplitude of the first four harmonics of power-line frequency. The harmonics measured are those superimposed on a 110-v 60-cps voltage. The device described here has five ranges of 0.3 to 30 volts full scale, with outputs for continuous monitoring of each harmonic.

### *Filter Outputs*

Four band-pass filters are tuned to each of the harmonic frequencies and a vtvm measures the voltage at each filter output. A bridged-tee filter, inserted between the input terminals and the filters reduces the ambient 10-v 60-cps component to about three volts. The bridged tee is matched to the filters by a 6AQ5 cathode follower.

Each filter consists of a single constant-K section utilizing high-Q torroids and has an iterative impedance of 1,000 ohms. More than 40-db attenuation at adjacent harmonics is achieved. Attenuation, measured from the input terminals to the output, is adjusted to 40 db by the 1,000-ohm potentiometers on the filter outputs.

Since simultaneous outputs of each harmonic frequency were required, a separate cathode follower was used in each channel. The circuit could have been considerably simplified by eliminating all but one of the cathode followers and reducing the power supply capacity accordingly. Also, since the series inductor and shunt capacitor have the same value in each filter section, size and cost savings could be achieved by switching only the series capacitor and shunt inductor when changing frequency, rather than the entire filter section.

The only difficulty encountered in the construction of this device was a slight amount of saturation of the 10-henry inductor in the bridged tee, resulting in a shift of resonance as the input voltage was varied from 0 to 120 v. This condition was alleviated by reducing the Q somewhat with a 740-ohm resistor in series with the inductor.

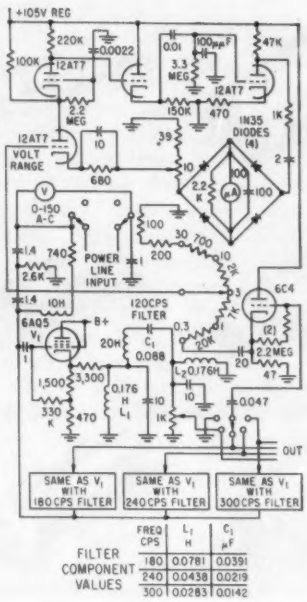


**FIG. 1—Tuned voltmeter construction has five ranges of 0.3 to 30 v full scale**

**Front panel view of tuned voltmeter designed for power system analysis**

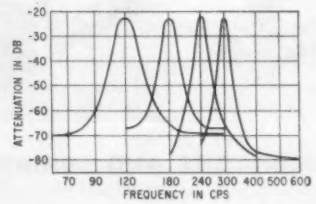


**FIG. 2—Response curve of selective voltmeter filters**

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# Passive Elements Form Time Delay

By ALFRED A. WINDSOR, Radiation Laboratory, University of California, Berkeley, Calif.

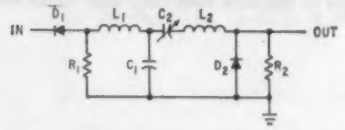



FIG. 1—Delay times from 5 usec to 5 millisec are produced by circuit with stability better than 0.1 percent

VARIABLE time-delay circuit combines maximum reliability and stability with minimum cost. These characteristics are obtained by using only passive elements.

A high-Q series *L-C* diode circuit rings one-half cycle in a very jitter-free way following an impulse charge on the capacitor. In Fig. 1, coil $L_1$ is made much smaller than coil $L_2$. This is done to charge capacitor $C_1$ rapidly enough so that $t_1$ in Fig. 2 can be considered the beginning of the time delay period. Capacitor $C_1$ is made large in order to give capacitor $C_2$ first order control and to keep a back voltage across diode $D_1$.

The design equations become the half period of a series-resonant circuit consisting of capacitors $C_1$ and $C_2$ and coil $L_2$, so that

$$\tau = \pi \frac{L_2 C_1 C_2}{C_1 + C_2} = t_2 - t_1$$

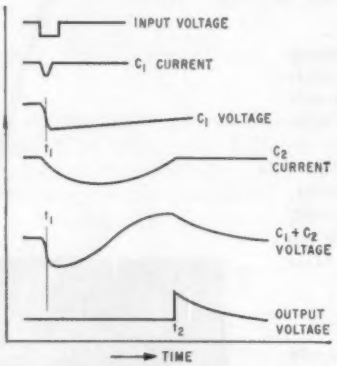



FIG. 2—Circuit produces indicated current and voltage waveforms

As current through the circuit approaches zero, resistance of diode $D_2$ becomes high. Voltage across $C_1$ plus voltage across $C_2$ appears across $R_2$ with a rise time *of* $L_2/R_2$ sec. Capacitor $C_1$ is discharged by $R_1$ in $R_1C_1$ sec.

Delay units have been built with delay times ranging from 5 μsec to 5 millisec. These units have a stability of better than 0.1 percent of delay time in the presence of temperature, humidity and magnetic-field changes.

Although polarity and amplitude of the output pulse changes, it could readily be restored to the same value as the input with a pulse transformer.

# Plastic Blocks Mount Accelerometers

By C. N. GILES, Sandia Corp., Albuquerque, New Mexico

PIEZOELECTRIC accelerometers are frequently used in environmental tests of newly developed equipment. They offer small size, high frequency response and are self-generating.

Mounting accelerometers on a specimen requires that the test engineer drill holes properly spaced in the specimen.. It is difficult to mount accelerometers on specimens that have thin walls and may be hermetically sealed.

### *Block Mounting*

Our test department has been cementing Lucite blocks on the surface of the specimens to be tested in vibration or shock with Dura-Kore dental cement. The plastic blocks must have at least three smooth faces which are machine drilled in such a way that the single-stud accelerometer mounting holes are perpendicular to the faces and are 90 degrees apart with respect to each other.

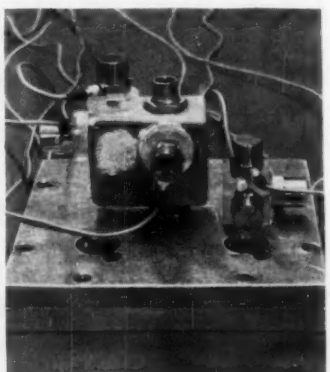
Two of the accelerometers measure transverse acceleration, while the third measures acceleration along the axis of excitation. This arrangement allows measurement of vibration along three mutually perpendicular axes. This method also eliminates the need for remounting accelerometers when changing specimen orientation on the vibration table.

The block material is not critical except for weight, which should be kept to a minimum. The size of cubes depends on accelerometer size and clearance needed for connectors. A common size is one inch.

### *Single Mounting*

A tapped plastic washer ¼ inch thick may be used in cases where mounting space is limited and only one axis of vibration is to be measured. Diameter of the washer is normally as large as the diameter of the accelerometer.

When tightening the accelerometer into the plastic block, the connector may stop in an inaccessible location. If it does, this problem



Dental cement is used to attach plastic blocks in equipment. Accelerometers are screwed into holes drilled in plastic in three axes

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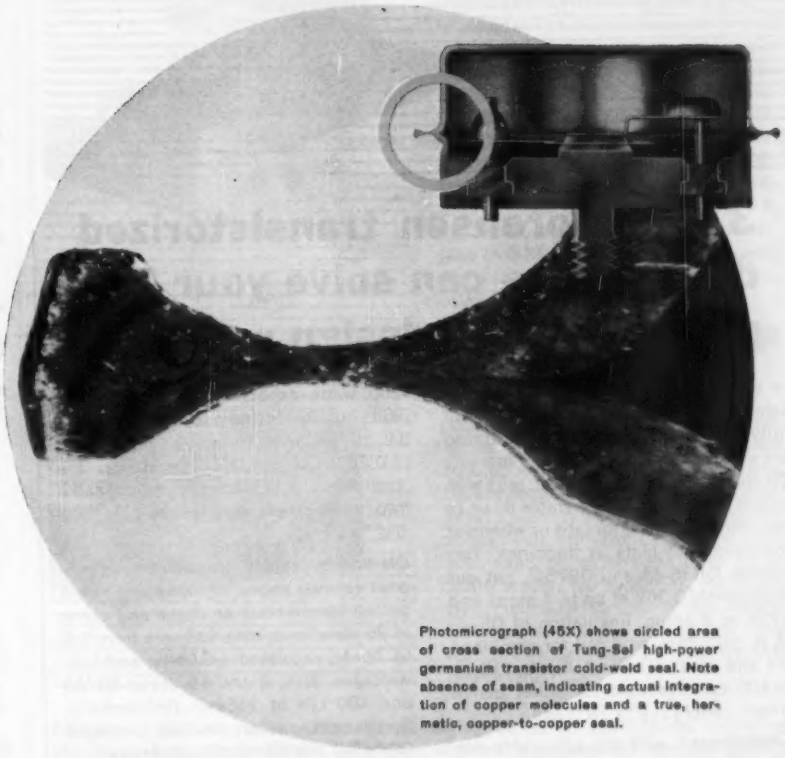
# Now

# High power transistors with new **cold-weld** seal

**Improved cold-weld seal gives new Tung-Sol high-power transistors three-way quality boost**

- True hermetic, copper-to-copper seal improves transistor thermal characteristics.
- Elimination of heat-damage, heat-caused moisture and "splash" increase reliability.
- Vacuum-tight, moisture-proof cold-weld seal lasts even through "breathing" over long life operation.



Photomicrograph (45X) shows circled area of cross section of Tung-Sol high-power germanium transistor cold-weld seal. Note absence of seam, indicating actual integration of copper molecules and a true, hermetic, copper-to-copper seal.

Once again Tung-Sol shows the way. Now, for the first time, Tung-Sol brings designers high-power germanium transistors with quality benefits of the advanced cold-weld seal.

The new Tung-Sol types feature a stud-mounted package and maximum collector current of 13 amps. Military environmental tests combine with the radioactive gas leak detection test to assure maximum reliability.

Technological advancements such as this keep Tung-Sol ahead of the field. For full data on the new high-power switching transistors . . . to meet any need with the latest in transistor design and efficiency, contact: Semiconductor Division, Tung-Sol Electric Inc., Newark 4, New Jersey.

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for lab, production test, test maintenance, or as a component or subsystem in your own products

## 3 new Sorensen transistorized d-c supplies can solve your lab, production and design problems

In the Sorensen "Q" Series, you can select from the most complete line of fully transistorized, highly regulated low-voltage d-c supplies on the market: **QR-Nobatrons,** (shown above, left) with output continuously adjustable down to zero volts, are ideal for labs or wherever maximum flexibility is required. Two models, QR36-4A and QR75-2, put out respectively 0-36V at up to 4 amps and 0-75V at 2 amps. Regulation of QR36-4A is ±0.025% or 4 MV for combined line and load variations. Input: 115vac 50-400 cps available for either bench or rack-panel (5½" x 19") use.

**Q-Nobatrons®,** with 2:1 adjustable output, can render outstanding service in semi-permanent lab set-ups, in production test, or integrated into your own product. Available in 15 models up to 200 watts capacity with 6, 12 or 28 volts out. Specs and packaging are similar to QR models above. Models for ±0.25% or ±0.05% regulation are available. Lower wattages are available two to a single rack panel (3½" or 5¼" x 19").

**QM-Series,** solder-into-the-circuit supplies (shown above, right) mount like a potted transformer or choke and come in 36 variations: nine voltages from 3.0 to 36vdc, regulated ±0.05%; and four wattages, 2, 4, 8 and 15. Input 50/60 and 400 cps at 115vac. (Incidentally, Sorensen also offers similarly packaged DC-to-DC and DC-to-AC converters.)

Ask us, or your nearest Sorensen representative, for the complete story on these precision transistorized regulated d-c supplies. 8.42

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can be overcome by inserting shim washers under the accelerometer. Each washer can be made equal to ¼, ½ or ¾ turns of the accelerometer mounting screw.

The surface should be clean and all paint should be removed. Surface smoothness is not critical since cement fills normal irregularities. The plastic block may be fitted to a curved surface by shaping it with a knife or file.

The dental cement is easily mixed in sufficient quantities for each mounting block. The mixture should be about the consistency of paste. For convenience, it may be mixed directly on the surface of the block to be attached to the specimen. The block is then pressed into position and oriented before the cement sets.

After completion of tests, the accelerometers should be removed first. The block may then be removed from the specimen by tapping it with a small metal hammer. The block snaps free and it may be reused in future tests in the same manner.

## Time and Pulses Control Gates


By J. K. GOODWIN
East Leake, N. Loughborough, Leics, England


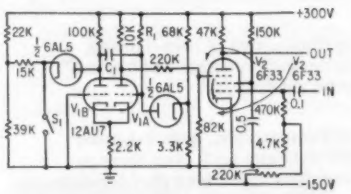


**FIG. 1—When switch $S_1$ is closed, the astable multivibrator opens the gate for period determined by the values of $C_1$ and $R_1$**

MODIFICATIONS of a pentode gate were required in developing pulsing circuits. One circuit is a time-controlled gate, and the other is synchronized by the incoming pulses.

### *Time-Controlled Gate*

The pentode gate in Fig. 1 is controlled by the period of an astable multivibrator. The multivibrator is conventional in most respects, with $C_1$ and $R_1$ establishing duration.

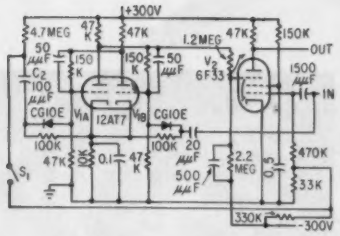


**FIG. 2—When switch $S_1$ is closed, gate is opened. Negative-going trailing edge of pulse closes gate again**

Initially tube $V_{1A}$ is conducting, and its plate potential is d-c coupled to the suppressor grid of the gate, keeping the gate closed. Closing switch $S_1$ causes the 6AL5 diode to conduct. The resulting drop in voltage at its anode is coupled to the control grid of $V_{1A}$, switching the multivibrator.

The increase in plate potential on $V_{1A}$, is applied to the suppressor of the gate. This voltage permits the gate to pass pulses applied to its control grid.

### *Synchronized Gate*

The circuit shown in Fig. 2 has a continuous train of pulses applied to the control grid of the gating tube. When switch $S_1$ is closed, the next pulse of the train opens the gate and then shuts the gate after itself.

If tube $V_{1A}$ in the scaling circuit is conducting, the drop in voltage at its plate holds the suppressor grid of the gate tube below cutoff. Closing switch $S_1$ lowers control-grid potential on $V_{1A}$, cutting it off. The rise in plate voltage is applied to the suppressor of $V_2$, permitting it to conduct.

With the gate open, the next positive pulse is permitted to pass through it. The positive going portion of the pulse has no effect on the scaler because of the effect of the input diode.

However, the negative-going trailing edge of the input pulse switches $V_{1A}$ on again, closing the gate.

This circuit was developed so that accurate synchronization of the gate with incoming signals could be achieved independently of switch $S_1$. Although the fastest prf used was only 300 pps, prf could be increased by taking care that rise and decay times are kept short.


# NEW IDEAS IN PACKAGED POWER

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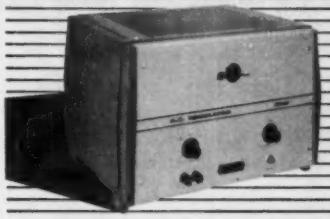
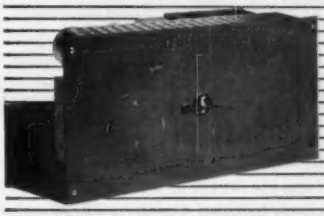


**0.01% regulation**—Why be half safe? You can get a-c line voltage regulation to the exact degree of precision you need from Sorensen. Model 2501 (left) regulates a-c line voltage to ±0.01% at 2500 VA. Other Sorensen a-c models range in precision from meter calibrators to rugged "constant voltage transformers," designed to give you maximum volt-amps per dollar.

**Fully-transistorized regulated d-c supplies**—The most complete line of transistorized low-voltage d-c power supplies on the market—like the new Model Q6-2 (left)—is offered by Sorensen. Regulation accuracy is ±0.25% (line and load combined). Life is exceptional. Response speed is extremely fast. They come with voltage adjustable over 2:1 range (Model Q Series) in 6, 12, 28 vdc and capacities to 200 watts. Also in 0-36, or 0-75 vdc continuously variable "Rangers" (Model QR Series) of 150-watt capacity.



**Here's a d-c workhorse for rack-panel equipment**—New Sorensen Model MD supplies feature magnetic regulation, semiconductor rectifiers, capacitance-input filters—and low cost. What's more you get any factory preset voltage you want, from 2.5 vdc to 1000 vdc. Available in 8 sizes from 25 to 3000 watts. No switches, no fuses (short circuited output is not recommended, but is not damaging). Ideal for powering your 19" rack-panel equipment.

Sorensen has many other ideas for packaging power to your needs, including standard off-the-shelf models, both electronic and transistorized, to take care of almost every need for controlled power—whether ac or dc, low or high voltage, low or high current. Ask for the latest Sorensen catalog. And let Sorensen engineers talk over with you a complete power system for your complex electronic equipment.

a-6

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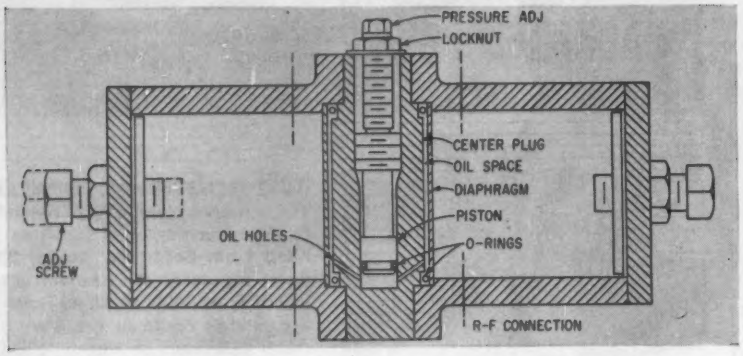
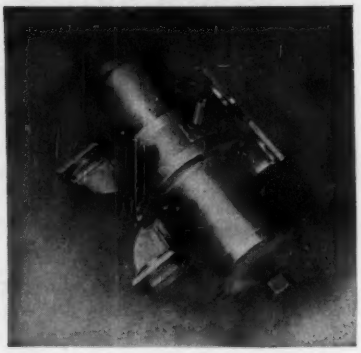



Cross-sectional view of the dual-cavity discriminator



Complete hydraulic tuned unit

# Dual-Cavity Microwave Discriminator

By MARVIN RUDIN, and RICHARD E. SHAFER and BRUCE W. BAKER

Electronic Systems Engineer, Aeronutronic Systems Inc., Glendale, Calif.

DOPPLER RADAR systems require a precise and stable reference oscillator or stalo to achieve low noise performance. An ordinary microwave oscillator, such as a reflex klystron, is too microphonic under high vibration levels to be used without stabilization.

Since the oscillation frequency of a klystron can be controlled by its reflector voltage, a stabilizing voltage can be derived from a pair of reference cavities forming a microwave discriminator. This technique transfers the stability problem from that of stabilizing a klystron cavity to that of stabilizing and tracking a pair of separate high-Q reference cavities. None of the restrictions from electron beam coupling or heat formation inherent to klystron cavity design are present with the new technique.

### Basic System

A block diagram of a two-cavity stalo is shown in Fig. 1. Power is coupled from the output line and fed to control cavities 1 and 2. Their output is crystal detected in opposite polarity and combined at the amplifier input to form a frequency discriminator response curve as shown in Fig. 2.

If the output frequency of the klystron should try to vary because of vibration, thermal expansion or other causes, a correction voltage is

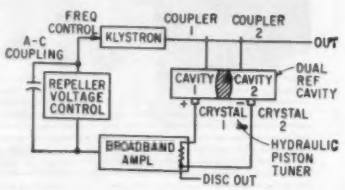



FIG. 1—Block diagram of the dual-cavity stable reference oscillator

generated by the discriminator. The voltage is amplified and applied to the klystron repeller to hold the frequency close to its initial value. The heart of the frequency control loop is its reference, the dual-cavity discriminator. It must be rugged, tunable over a wide range of frequencies and the two cavities must track closely to retain maximum slope at the zero crossover point shown in Fig. 2.

High vibration resistance, temperature stability and precision of frequency track of the discriminator are made possible by a central hydraulic tuning mechanism. Diaphragms forming the adjacent end of each cavity are deflected to tune the cavity. Deflection is accomplished by hydraulic pressure controlled by a threaded piston, accessible at the side of the cavity body.

Diaphragms are made of 0.0625-in.-thick 4140 alloy, heat-treated to 138,000 psi yield minimum, ground to equal thickness, silver-plated and rhodium flashed. Each cavity is ground to 0.0001-in. tolerance to obtain uniform deflections of both diaphragms for accurate frequency tracking. The combination of steel diaphragms separated by an incompressible fluid provides high resistance to vibration because effectively a rigid sandwich structure is formed with the steel diaphragm as the skin.

### Determining Dimensions

As the ambient temperature varies, the center oil space volume varies. Size of the center plug was determined initially by volumetric calculations. Final dimensions were determined empirically by incrementally drilling a small hole in the center plug. Variations in expansion of the space, the plug, the oil and the cavity dimensions were then

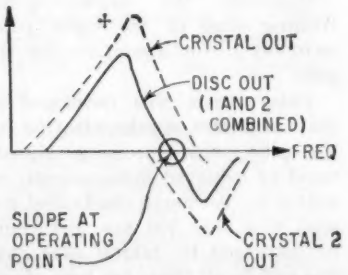



FIG. 2—Discriminator frequency response

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**Simplify design**
**Speed production**
**Save money**

You can save many expensive engineering hours because designers no longer need to plow through thousands of eyelet specifications. Over 20 years' experience has shown that a very high percentage of all eyelet work can be done with the 7 United Standard diameters.

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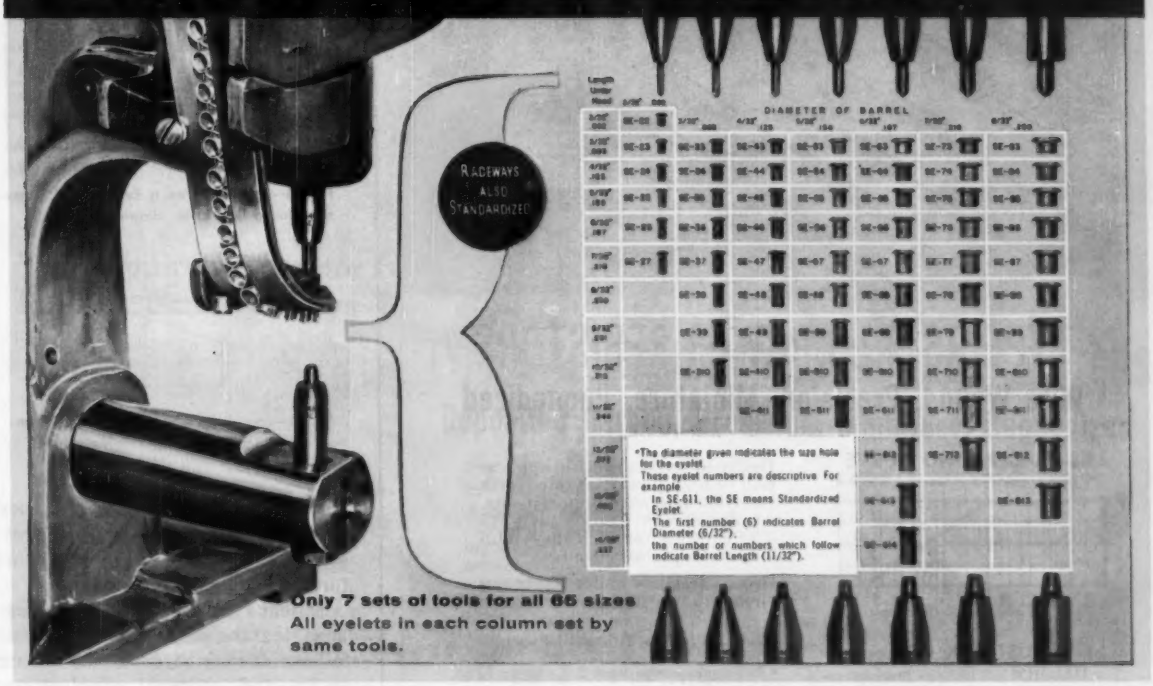
RACEWAYS ALSO STANDARDIZED
DIAMETER OF BARREL
*The diameter given indicates the size hole for the eyelet.
These eyelet numbers are descriptive. For example
In SE-611, the SE means Standardized Eyelet.
The first number (6) indicates Barrel Diameter (6/32").
the number or numbers which follow indicate Barrel Length (11/32").

**Only 7 sets of tools for all 65 sizes**
All eyelets in each column set by same tools.

Only *SEVEN* sets of tools needed for all 65 sizes! This means that tooling is reduced as much as 90%. With United's closely co-ordinated system of Standardized Eyelets and Eyeleting machines, eyelet grip can be increased as much as 1000% (for instance, from .093″ to .437″) without a single change in drill, punch, or setting tool. Result: greatly reduced installed costs and true fastener economy.

Purchasing problems are eliminated. United Standardized Eyelets are carried in stock at key points: United's Shelton Eyelet Division plant near New York and branch offices in Chicago and Los Angeles. Low eyelet costs for you are ensured by United's constant high volume production on a relatively small number of sizes.

Inventory is greatly simplified. Fewer sizes do more jobs. Actual experience of thousands of users for over two decades has shown that United Standardized Eyelets and co-ordinated Eyeleting machines can reduce the number of eyelet sizes carried in stock an average of 66⅔%.

Precision made in standard increments of 1/32″ in both barrel O.D. and length, each one of the 65 United Standardized Eyelet sizes has a standard relationship in dimension and proportion to every other eyelet in the series. They are designed to save you money. Start to-day to enjoy the advantages of United's Standardized Eyelets. Write or call us for complete information.

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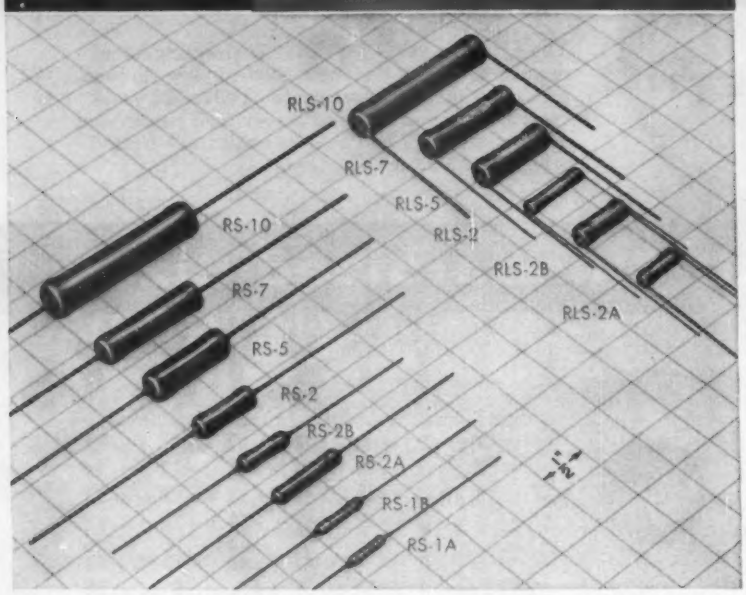
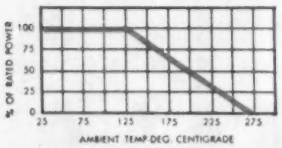



# TYPE RS, RLS POWER RESISTORS

## Wire Wound, Precision, Miniature, Ruggedized

**RS-2A DERATING CURVE**

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Designed for the specific application of high power, coupled with precision tolerance requirements. Available with axial leads – RS TYPE; with radial leads – RLS TYPE (for printed circuitry).

Gives reliability under severe environmental conditions.

- Rated at 1, 2, 3, 5, 7 and 10 watts.
- Resistance range from 0.1 ohm to 175K ohms, depending on type.
- Tolerance: ±0.05%, ±0.1%, ±0.25%, ±0.5%, ±1%, ±3%.

**TEMPERATURE COEFFICIENT:** Within 0.00002/degree C.

**OPERATING TEMPERATURE RANGE:** −55° C. to 275° C.

**SMALLEST IN SIZE:** 3/32" x 13/32" to 3/8" x 1-25/32"

**COMPLETE PROTECTION:** Impervious to moisture and salt spray.

**WELDED CONSTRUCTION:** Complete welded construction from terminal to terminal.

**SILICONE SEALED:** Offers maximum resistance to abrasion, and has high dielectric strength.

**MILITARY SPECIFICATIONS:** Surpasses applicable paragraphs of MIL-R-26C.

*Write for Bulletins R-23, R-30*

mutually compensating.

The cavity body material is ¾-in.-thick 6061 aluminum alloy for vibration resistance with aluminum waveguide fittings dip-brazed to the cavity body. The cavity was honed slightly oversize initially, nickel-plated, honed and polished, then silver-plated and rhodium flashed for electrical conductivity and corrosion resistance. A highly-polished interior surface is required for low electrical power loss.

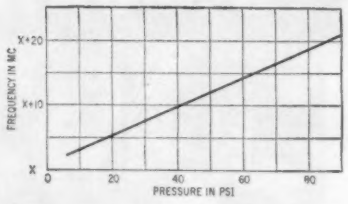


**FIG. 3—Frequency as a function of pressure for a 0.0625-in. diaphragm**

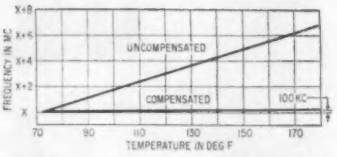


**FIG. 4—Frequency as a function of temperature for a 0.0625-in. diaphragm**

Figure 3 shows tuning frequency variation versus hydraulic pressure while Fig. 4 shows the same function versus temperature.

Salient performance specifications for the discriminator are as follows: Tunability, ±50 mc (using cavity and screws); single-screw tuning, ±15 mc; thermal drift, one part in $10^7$ per deg F and sensitivity as discriminator, 1.5 v per mc.

## New Chemical for Gyro Flotations

FLUIDITY is retained even in intense cold by a new gyro flotation material developed at Sperry Gyroscope Co. Although chloro-fluorocarbon fluids are commonly used, the new material is a bromine version of the same class of compounds. It remains viscous to less than −65 F.

Floated gyros incorporating the

**New flotation material (left) after being subjected to sub-zero temperature remains fluid. Conventional material has solidified**

new material will not require heat during storage at temperatures above −65 F. Also, the new fluid can be brought up to operating temperature in an extremely short time without the damage hazard inherent to older types of flotation materials.

## Tiny Neutron Detector Ignores Gamma Rays

DEVELOPED by Westinghouse, a new neutron detector consists of a tiny slice of silicon or germanium with a sensitive junction or layer near the top surface of the slab. On the top layer of this diode, a layer of uranium is deposited. Copper wires are soldered to the detector and it is sealed inside one end of a thin aluminum tube.

Slow-speed neutrons strike the uranium causing U-235 atoms to split apart. The created particles pass through the junction of the diode detector and upsets its electrical balance. The net result is an electrical pulse that can be detected and counted. The detector is almost completely insensitive to gamma rays. High-speed or fast neutrons do not cause appreciable fission of the uranium and are not detected.


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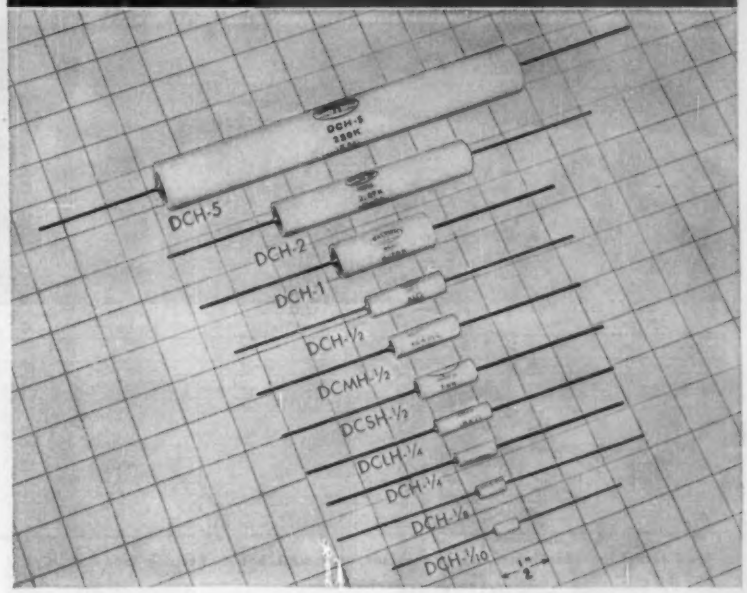


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## Deposited Carbon, Precision, Miniature, Ruggedized

A true hermetically sealed deposited carbon film resistor with outstanding stability and rugged performance characteristics. Excellent voltage coefficient, low capacitive and low inductive characteristics for dependable operation under difficult high frequency applications.

- Rated at 1/10, 1/8, 1/4, 1/2, 1, 2, and 5 watts
- Resistance range from 5 ohms to 600 Megohms
- Tolerance: ±1%

**TEMPERATURE COEFFICIENT:** 140 to 500 parts per million per degree C., depending on type.

**RUGGEDIZED:** Completely sealed with high temperature alloy solder in newly developed envelope of non-hygroscopic ceramic.

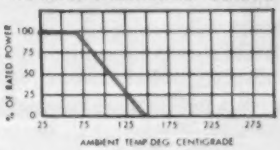
**SMALLEST IN SIZE:** .155" x 9/32" to .562" x 4-1/2".

**RESISTANCE ELEMENT:** Pure crystalline carbon particles that contain no binder or filler.

**MILITARY SPECIFICATIONS:** Surpasses MIL-R-10509B.

*Write for Bulletin R-27*

**TYPICAL DERATING CURVE**

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Just outline your specific situation.

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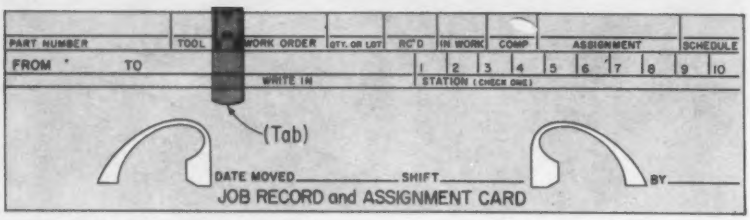
COLUMBUS, NEBRASKA

# Kits Streamline Prototype Tests

By W. C. BOGART, Pilotless Aircraft Div., Boeing Airplane Co., Seattle, Wash.




**Lead technician coordinates test operations at control board, keeping job records and assignments listed on cards like the copy shown**

TEST EQUIPMENT kits provide a flexible, efficient, cost-oriented electronic component test system during prototype production of the Bomarc ground-to-air missile. The system is adaptable to changing design and increasing production rates.

In R&D testing, equipment is assembled by technicians as required. At peak production, automatic go-no-go test stations will be permanently positioned on the assembly line. The test kits provide an interim system which meets the increasing volume of test operations encountered when phasing into a production program.

Factors taken into account include minimizing technical effort in assembling test equipment, control of equipment for calibration, certification and inventory, multiple use of available equipment, minimum number of test stations for any production rate and conservation of space.

Test equipment kits are stored in an instrument crib in the center of the test area. Each kit contains equipment required for a specific test. Control and inventory of the kits rests on a storekeeper in charge of the instrument crib.

From an operations control board at the instrument crib, a lead technician determines the status of operations at each test station and what electronic components are on hand ready for test. He assigns new test operations to stations at which a job in process is about to be completed.

The lead technician uses open files of job record and assignment cards. The cards are coded with removable colored plastic tabs. The tabs tell at a glance whether work is on schedule or delayed for various reasons.

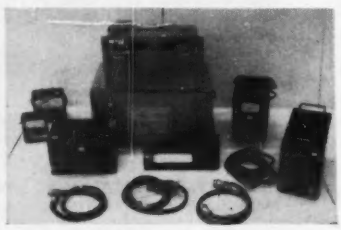
When the storekeeper receives a test assignment from the lead technician, the storekeeper selects the correct kit and has a dispatcher deliver it to the test station. The dispatcher returns the kit previously used at the station.

The storekeeper checks the parts of the returned kit for damage, sends to instrument test those parts which are ready for certification or calibration, completes the kit with spare parts and puts it in storage.

Test equipment involved in a particular test is usually contained in a single wooden chest. Multiple use test equipment pieces are grouped in strategic locations in the crib. Each piece of equipment is numbered. When the storekeeper selects a kit, he may add several pieces of multiple use equipment. Equipment required for any test is listed in the storekeeper's file.

**Bomarc electronic component is checked out with kit at test station**

**Storekeeper selects kit in instrument crib**



**Typical test kit contains special equipment (in front of chest) and multi-use equipment**

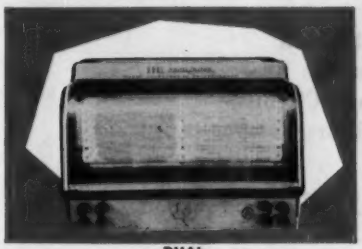
## Machine Sorts Transistor Dice

TRANSISTOR DICE measuring machine with automatic feed minimizes handling breakage while speeding the sizing operation at Sylvania Semiconductor Products Division, Woburn, Mass.

Two rotating gage rolls are set at a slight angle. Each die works its way down the valley between the rolls until the space between the rolls is wide enough for the die to slip through. Small boxes beneath the rolls catch the dice according

# What's your application for versatile recti/riter® recorders?

*TI's Applications Engineering Department invites your requests for technical assistance in OEM or end uses. Here are a few of the present applications.*

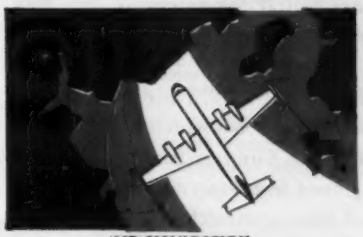


**SINGLE** and **DUAL**

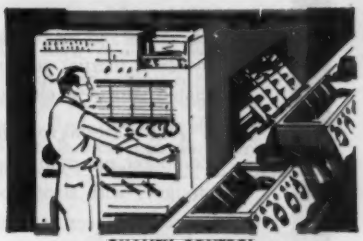
Rectilinear Galvanometric Recorders, with a wide choice of sensitivities and "recti/riter" accessories, offer the most complete ranges available for recording electrical parameters from many types of transducers.

**MISSILE TESTING**
—a bank of "recti/riter" units record voltage frequencies and currents.

**MEDICAL RESEARCH**
—used with rate meters and nuclear scanners . . . also used to monitor rate of impurities in vaccines.



**AIR NAVIGATION**
—used to monitor ILS beams . . . also used to monitor LORAN signals.

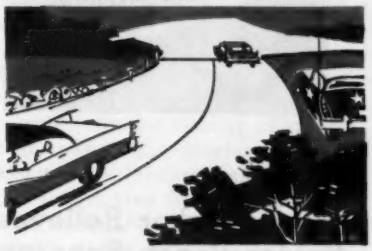


**QUALITY CONTROL**
—used on numerous production lines to check sizes and contours of parts, as well as assembly rates.

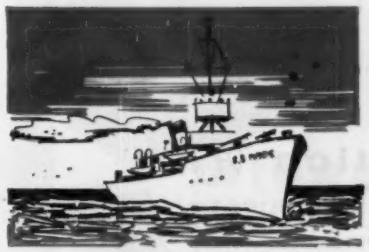
**METEOROLOGICAL**
—records wind directions and velocities . . . also used in studies of Aurora and air glow through scintillometer counters.

**AUTOMATIC COMPUTERS**
—for studying stability of electrical parameters that affect accuracy.

**OIL EXPLORATION**
—used in well logging as well as airborne magnetometers and scintillometers.



**RADAR SPEED METERS**
—used in police vehicles to visually record speed of passing motorists.



**OCEANOGRAPHY**
—records wave frequency and magnitude . . . also monitors underwater pressures.

**ATOMIC TESTING**
— used to measure radiation fall-out at test centers and nuclear installations.

*TI will custom manufacture "recti/riter" recorders to your specifications for OEM use. Write for complete information.*

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Also positions for: engineering handbook writers; computer programmers; standards hardware parts designer with strong background in fasteners; research engineer to plan and execute research program involving inorganic materials in electronic equipment and to perform chemical analysis of materials; senior estimators for manufacturing cost analysis proposals.

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Downey, California

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NERVE CENTER OF THE NEW INDUSTRIAL ERA

**Dice measuring equipment being charged. Charging is normally done through opening in top of dust cover**

to their thickness. Either germanium or silicon dice can be measured within a tolerance of 0.0001 inch or better.

Dice are fed from a vibratory feeder into an escapement. Discharge of the dice onto the rolls is timed by static electricity.

## Revolving Drum Delivers Parts

PARTS SELECTION system for bench assembly delivers parts in baskets on a rotating drum horizontally mounted at the rear of the bench. In one application, 32 baskets are carried on 8 level platforms. The platforms are rotated to bench level by a foot control. The parts selector was built by Diebold, Inc., as a modification of its motorized office filing machine.

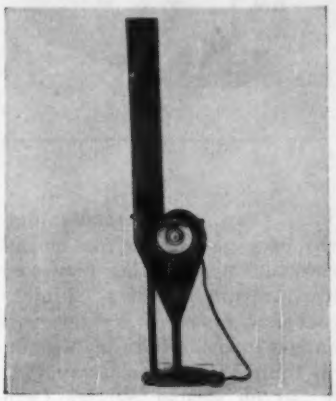
## Fume Sucker Relieves Solder Bench Sneezes

By **RONALD L. IVES** Palo Alto, Calif.

LONG-CONTINUED work at the soldering bench, under conditions of poor ventilation, produces attacks of sneezing in some workers, and a coating of condensed rosin

on eyeglasses. Tests showed that the nasal discharges of some workers contained appreciable amounts of finely-divided rosin; and medical evidence indicated that the "machine gun" sneezing was due solely to mechanical irritation, with no indication of chemical poisoning or allergy.

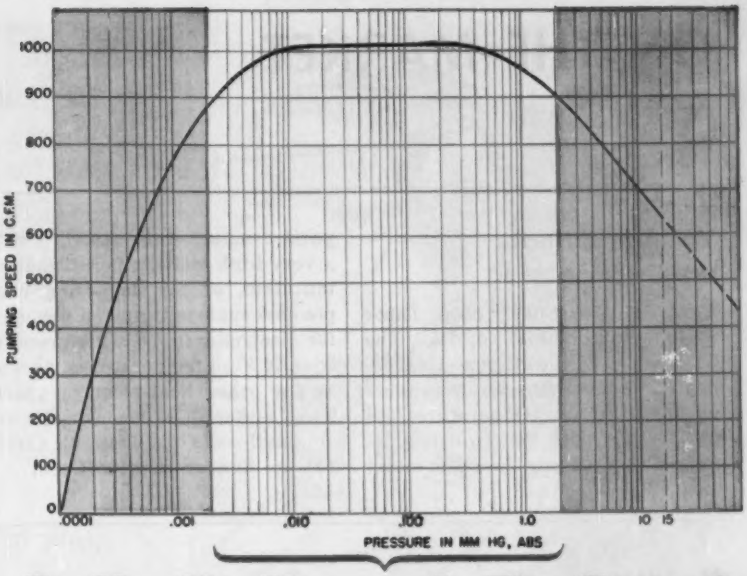
Preliminary tests showed that a small exhaust fan, placed near the soldering position, removed the rosin and other soldering fumes, and relieved the sneezing, eye irritation, and eyeglass-coating to a great extent.



Fume sucker mounted on stand for bench use

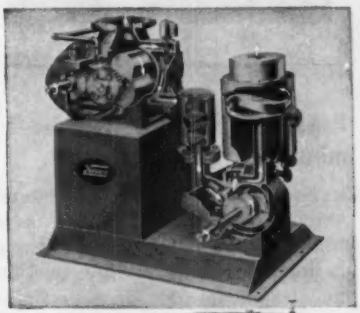
Permanent relief of this nuisance trouble was brought about by the construction of a number of portable fume suckers, which could be placed adjacent to the soldering position. These were made from a small blower (L-R 3, Model 8472); mounted on a heavy base (old microphone stand), and fitted with a stack, to carry the discharge upward, away from breathing level.

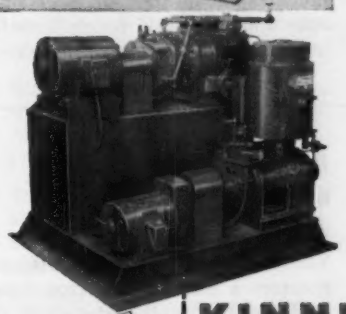
As constructed, this portable fume sucker removes approximately 70 cubic feet of air per minute from the vicinity of its intake, effectively clearing the air about the soldering position without also sucking in small parts and wire ends. For effective use, the intake should be within 18 inches of the soldering position, and preferably about 8 inches above the source of flux fumes. Power consumption is about 40 watts, estimated life is in excess of 10,000 hours, and total cost is about $35.00 each in small lots.


## Do You Use Vacuum In This Range?

From millimeters to microns . . . in this region the significant economy of the KINNEY KMB Mechanical Booster Pump is self-evident, as shown by the performance curve above. And, this high efficiency is doubly attractive because these KINNEY Pumps provide *clean, dry* Vacuum . . . no backstreaming . . . automatic operation . . . no stalling problems from gas bursts.





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The KINNEY KMB Pumps have proven themselves in the most difficult applications. They feature high pumping speed in the low micron range and their design provides for addition of interstage cold traps with minimum plumbing or other complications. Their performance, even where outgassing of materials renders other pumps inoperative, stamps them as the major contribution of the decade in High Vacuum service.

KMB 1200 with free air displacement of 1230 cfm. Other models provide pumping speeds from 30 cfm to 5100 cfm.

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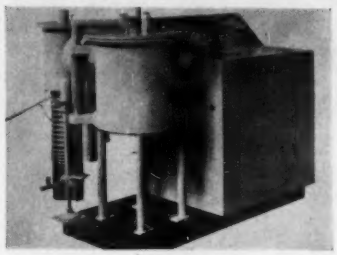
# ON THE MARKET

## Vacuum Furnace resistance-heated

F. J. STOKES CORP., 5500 Tabor Road, Philadelphia 20, Pa. The ST-58-84 cold-wall resistance-heated vacuum furnace is capable of operating at temperatures up to 2,200 C (4,000 F). Unit is suitable for sintering powder metal parts compacted of materials with a very high melting point, such as tantalum, or for degassing components such as tungsten elements for electronic tubes, which require equally high temperatures, as well as for other heat-treating operations, either in experimental work or small-scale production. **Circle 200 on Reader Service Card.**

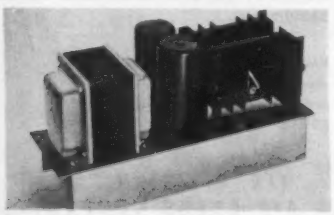


## Magnetrons voltage-tunable

GENERAL ELECTRIC CO., Schenectady 5, N. Y. Packaged voltage-tunable magnetrons, consisting of tube, magnet, cavity, and associated accessories, are now being offered as pre-tuned and adjusted units. They are essentially high-frequency generators for the microwave bands. Tuning characteristics are linear over a 1.7 to 1.( frequency range or greater, with changes in anode voltage. Mechanical tuning is not necessary. **Circle 201 on Reader Service Card**

## Pressure Switch miniature size

MELETRON CORP., 950 N. Highland Ave., Los Angeles 38, Calif. A new miniature pneumatic pressure switch is now available in two models—model 610 for gage pressure and model 617 for differential pressure. Both have an operating range of from 0 to 30 psi, a temperature range of −55 to +160 F, and a port size of 1/8-27 ANPT. The switches are 1½ in. in diameter, approximately 2 in. long and weigh approximately 1.2 oz. A feature is the potted integral snap-action, spdt electrical switch. Solder terminals are provided. **Circle 202 on Reader Service Ca**

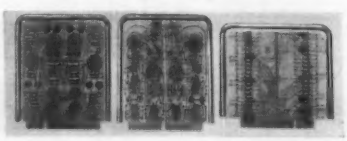


## Power Supplies transistorized

DRESSEN-BARNES CORP., 250 N. Vinedo Ave., Pasadena, Calif., announces a line of fully transistorized power supplies designed for use as components in original equipment. Seven voltage ranges are provided—from 5-7 v at 3.0 amperes, up to 27-32 v at 1 ampere. Regulation for these units, line and load combined, is 0.5 percent; maximum transient no load to full load is 200 mv. Ripple is 2 mv rms; maximum operating temperature, 50 C. **Circle 203 on Reader Service Card.**

## Digital Components plug-in type

AERONUTRONIC SYSTEMS, INC., 1234 Air Way, Glendale, Calif., has developed a complete set of basic transistorized digital computer circuit packages. Individual circuits include flip-flops, diode logic boards, read amplifiers, write



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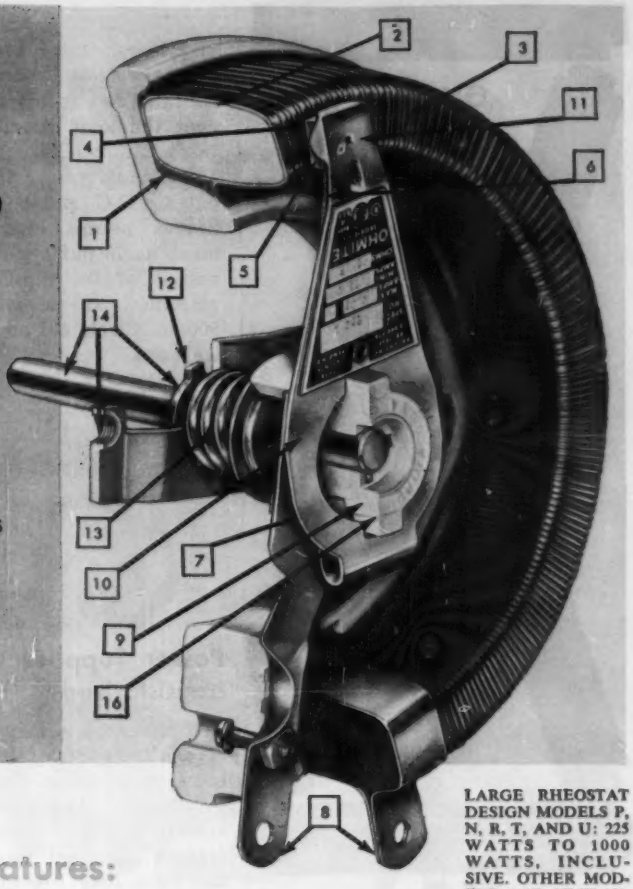
**NOW 11 Sizes! 12½ to 1000 Watts**

Ohmite offers you industry's most complete line of rheostats. All sizes are available from stock in a wide range of resistance values, including the NEW Model "E." Ten sizes are available to meet MIL-R-22A requirements in *each* of the 26 type designations.




LARGE RHEOSTAT DESIGN MODELS P, N, R, T, AND U: 225 WATTS TO 1000 WATTS, INCLUSIVE. OTHER MODELS ARE SIMILAR.

## 16 Quality Engineering Features:

1. Vitreous enamel bonds the core and base together into one integral unit.
2. The wire is wound over a solid porcelain core, and each turn is locked against shifting by vitreous enamel. Uniform or tapered winding.
3. Close graduation of control. Each turn of wire is a separate resistance step.
4. Large, flat surface upon which the contact brush rides.
5. Metal-graphite contact brush (varied to fit current and resistance) insures good contact, with negligible wear on the resistance wire.
6. Shunt pigtail of ample size carries the current directly to the slip-ring.
7. Large slip-ring of high-current carrying ability minimizes mechanical wear and provides connection from the moving contact to the terminal.
8. Potentiometer use. The rheostats are provided with three terminals so they can be used as potentiometers or voltage dividers.
9. High strength ceramic hub insulates the shaft and bushings from all live parts. All sizes will stand a 3000 volt a-c breakdown test to ground.
10. The contact arm is a long tempered steel spring which assures uniform contact pressure at all times. Cadmium-plated for corrosion resistance.
11. Rounded pivot holds contact brush in flush-floating contact with wire.
12. Stops which are keyed to the shaft and base limit the rotation—thus no torsional strain is imposed on the contact arm on stopping.
13. Compression spring maintains uniform pressure and electrical contact between slip-ring and center lead at all times.
14. Models H, J, G, K, and L: Phosphor-bronze retaining ring takes end-thrust. Models P, N, R, T, and U: Stop washer takes end-thrust. Steel shaft in brass bushing provides a wear-resistant, wobble-free bearing.
15. Ohmite rheostats meet requirements of NEMA and EIA (formerly RETMA).
16. There are only ceramic and metal in the construction of Ohmite rheostats—there is nothing to char, burn, shrink, or deteriorate.

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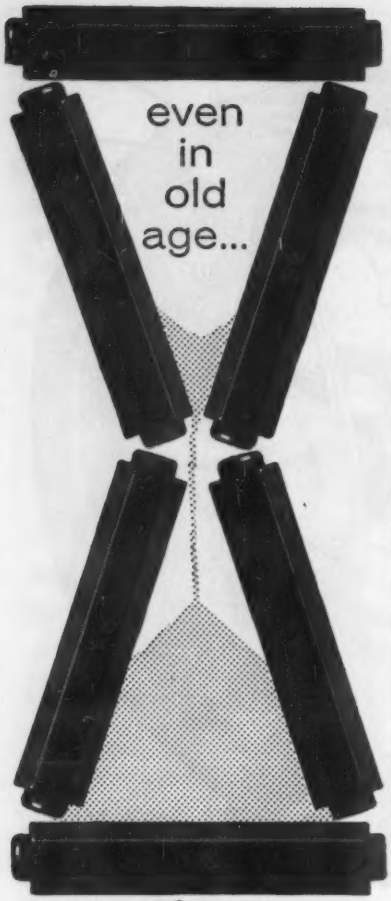
CIRCLE 53 READERS SERVICE CARD

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S. S. WHITE Molded Resistors retain their original values and never deteriorate due to age!

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For full details, write for our Bulletin 5409. We'll be glad to help you apply these high-quality, "all-weather" resistors to your product. Just drop us a line.

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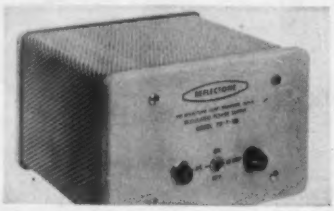
CIRCLE 54 READERS SERVICE CARD


amplifiers, and blocking oscillators. Each component board contains two identical circuits except the logic board, which contains 2-1, 2-2, 2-3, 1-4, 2-5 function "and" gates, and nine "or" gates. D-C pulse gating techniques permit operation of as many as 75 pulse gates from each output of the flip-flop and read amplifier, at frequencies up to 500 kc. **Circle 204 on Reader Service Card.**



## Power Supplies transistorized

THE REFLECTONE CORP., Post Rd. & Myano Lane, Stamford, Conn. Two more fully-transistorized power supplies are announced. Compact and light-weight, these supplies feature 3-percent load regulation and offer long life and high efficiency. For general purpose use, model PS-T-U6 has an output of 6 v at 2 amperes, while model PS-T-G12 provides a selectable output of 6, 12, or 18 v at 2 amperes. **Circle 205 on Reader Service Card.**

## Time Delay Relay multiple poles

BRANSON CORP., 41 So. Jefferson Road, Whippany, N. J. Type MT-RH-6 time delay relay features immediate reset at the completion of a delay cycle. It measures 2.25 cu


**FLIGHT DATA and CONTROL ENGINEERS**

*Cross new frontiers in system electronics at The Garrett Corporation.*

*High-level assignments in the design and development of system electronics are available for engineers in the following specialties:*

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1) **DESIGN ANALYSIS** Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

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**Forward resume to:**
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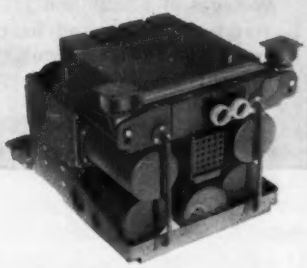
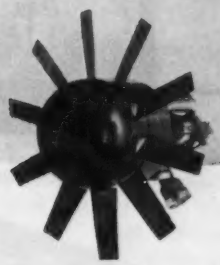
***The A3J "Vigilante," equipped with vital AiResearch subsystems***



Centralized Air Data Computing System

Refrigeration Package



Ram Air Turbine

North American Aviation's twin-jet A3J "Vigilante" is the Navy's newest attack weapon system... an all-weather, carrier-based, 30,000 lb. thrust aircraft which delivers both conventional and nuclear weapons from high or low altitudes at supersonic speeds.

Contributing to the success of the first aircraft produced under the Navy's weapon system management concept is the following AiResearch equipment:

***AiResearch Centralized Air Data Computing System*** provides information for the major flight data subsystems dealing with bombing, navigation, engine inlet control, radar, automatic flight control and includes cockpit indicators showing true air speed, altitude and engine inlet air temperature.

***AiResearch Environmental System Components*** for personnel and compartment air conditioning and pressurization include: cabin pressure regulators, safety valves, cabin refrigeration package, equipment compartment refrigeration package, primary heat exchangers, pressure suit heat exchangers and water-alcohol tanks for evaporative cooling.

***AiResearch Ram Air Turbines*** provide power for operation of surface controls, instrumentation and landing gear in case of emergencies. Also included are miscellaneous valves and electro-mechanical equipment.

Systems engineering, support services and systems management have enabled AiResearch to integrate these vital subsystems into North American's A3J.

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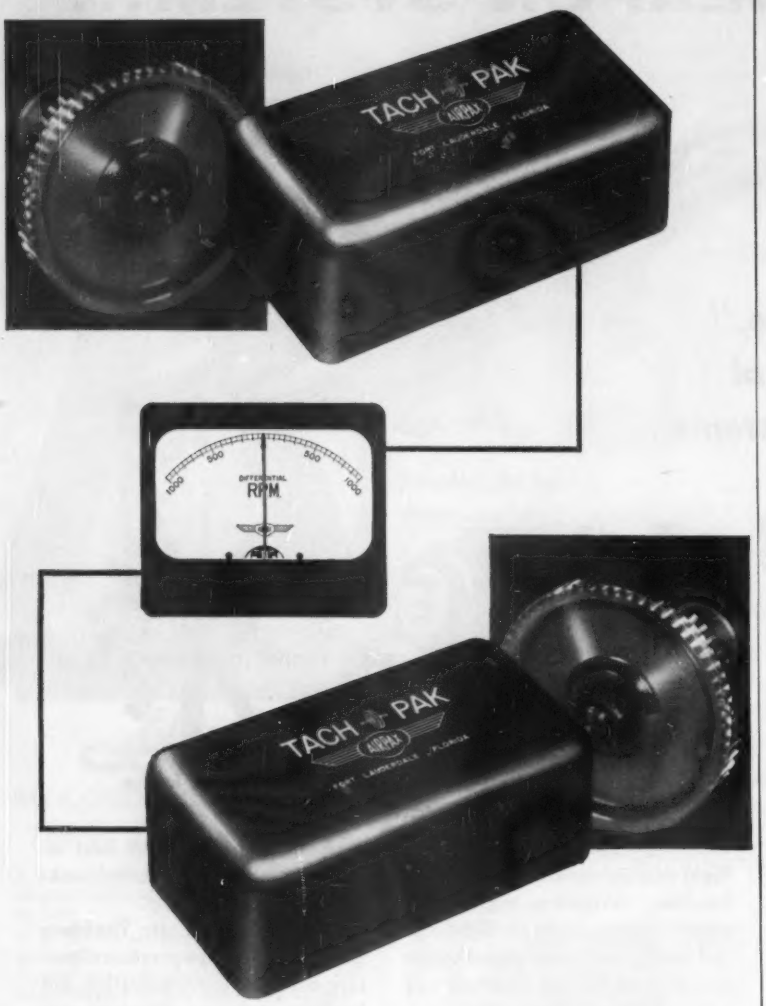
CIRCLE 56 READERS SERVICE CARD

AIRPAX

Differential Tachometer System




**The difference in speed between two rotating shafts is accurately sensed and indicated on a center-zero meter. Even slight variations are instantly transmitted to the indicator. The proximity magnetic pickups used with the system do not impede shaft rotation. Shaft speeds may be adjusted manually or, if a closed servo loop is used, a predetermined rotational speed difference may be maintained automatically.**

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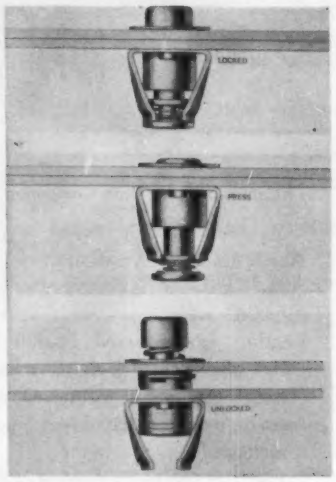
SEMINOLE DIVISION, FORT LAUDERDALE, FLORIDA

in. and weighs approximately 3 oz. Unit meets military requirements. Standard mounting arrangements are readily available. **Circle 206 on Reader Service Card.**

## Thermal Time Delay subminiature

G-V CONTROLS INC., Okner Parkway, Livingston, N. J. A new hermetically sealed thermal time delay relay has a seated height only $\frac{7}{8}$ in. above mounting panel and is designed to withstand continuous 20 g vibration at frequencies up to 1,000 cps. Contacts are spst, either normally open or normally closed. Rating is 2 amperes resistive at 115 v a-c or 28 v d-c. Time delays are factory set and sealed. Relays are offered in 10 standard delays from 2 to 75 sec and for standard heater voltages of 6.3, 28 and 115 v. Nonstandard delays and heater voltages available on special order. **Circle 207 on Reader Service Card.**




## Fastener quick release

DEUTSCH FASTENER CORP., P. O. Box 61072, Los Angeles 61, Calif. "Press to lock . . . press to unlock" is the way the company describes its new Pres-Loc fastener. Particularly suited for the aircraft, missile and electronic fields, they can be used for securing inspection ports, modular units, panels and all other sections requiring quick, simple installation and removal. These fasteners are easily

# TESTED AT 125°C UNDER FULL LOAD FOR 1,000 HOURS— LESS THAN 1% CHANGE

## *New ELECTRA Series 125 Precision Resistor*

Here is a brand new carbon film resistor that represents a greater-than-ever achievement in combining precision, stability and small physical size. Here is the kind of superior performance that formerly was available only in much larger, more costly components. It is a resistor that opens up a whole host of new possibilities in your design and engineering work. Unfortunately, space does not permit us to tell the whole story here. But your request will bring complete details by return mail . . . including prices.

**CHECK THESE OUTSTANDING TEST RESULTS***

| TEMPERATURE CYCLE | | | MOISTURE | | | LOAD-LIFE 125° C | | | TOTAL IMMERSION IN SOLDER AT 550° F. FOR 5 SECONDS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial | Final | % Change | Before | After | % Change | Initial | After | % Change | Initial | Final | % Change |
| 235.6 | 235.8 | .08 | 235.5 | 236.0 | .21 | 233.5 | 233.9 | .27 | 140.5 | 140.6 | .07 |
| 236.6 | 236.7 | .04 | 237.4 | 237.5 | .04 | 233.1 | 233.5 | .27 | 139.5 | 139.5 | 0 |
| 236.1 | 236.2 | .04 | 235.3 | 235.6 | .13 | 233.0 | 233.4 | .27 | 140.0 | 140.0 | 0 |
| 235.7 | 235.8 | .04 | 236.2 | 236.6 | .17 | 233.7 | 233.9 | .18 | 139.3 | 139.4 | .07 |
| 235.4 | 235.5 | .04 | 235.9 | 236.2 | .13 | 234.8 | 235.1 | .23 | 140.3 | 140.3 | 0 |
| 235.2 | 235.4 | .08 | 236.9 | 237.4 | .21 | 233.5 | 233.6 | .14 | 139.9 | 139.9 | 0 |
| 237.7 | 237.8 | .04 | 235.6 | 236.0 | .17 | 233.9 | 234.1 | .18 | 139.6 | 139.6 | 0 |
| 236.3 | 236.4 | .04 | 235.4 | 235.6 | .08 | 233.1 | 233.5 | .27 | 139.4 | 139.4 | 0 |
| 236.5 | 236.6 | .04 | 236.5 | 237.1 | .25 | 232.8 | 233.0 | .18 | 139.7 | 139.7 | 0 |
| 237.0 | 237.2 | .08 | 236.1 | 236.6 | .21 | 233.8 | 234.0 | .18 | 139.6 | 139.6 | 0 |

*Typical Data CF½ When Tested to Mil R10509B

| Electra Part No. | Mil Style | Wattage | Mil Resistance Range | Manufactured Resistance Range | Maximum Rated Voltage |
|---|---|---|---|---|---|
| CF⅛ | RN60B | ⅛ | 10 ohms 1 meg | 10 ohms 1 meg | 250 |
| CF¼ | RN65B | ¼ | 10 ohms 2 meg | 10 ohms 2 meg | 300 |
| CF½ | RN70B | ½ | 10 ohms 2.5 meg | 10 ohms 5 meg | 350 |

EXCLUSIVE NEW COATING IS THE KEY — Developed only after long study and experimentation, it is Electra's exclusive new Type R-5 coating that is primarily responsible for the superior performance of the new Series 125 Resistor. It is a coating that offers a new high in protection against heat, moisture, rough handling and other enemies of reliability.

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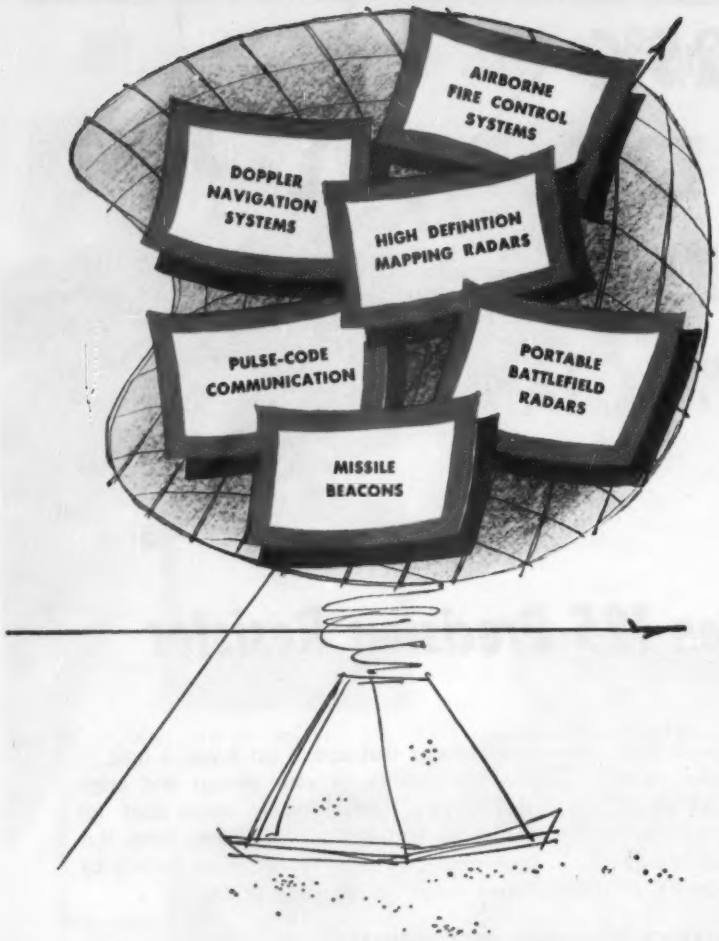


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installed and require no tools of any sort. A press of the thumb is all that is needed. **Circle 208 on Reader Service Card.**

## Integrating Servo with rate feedback

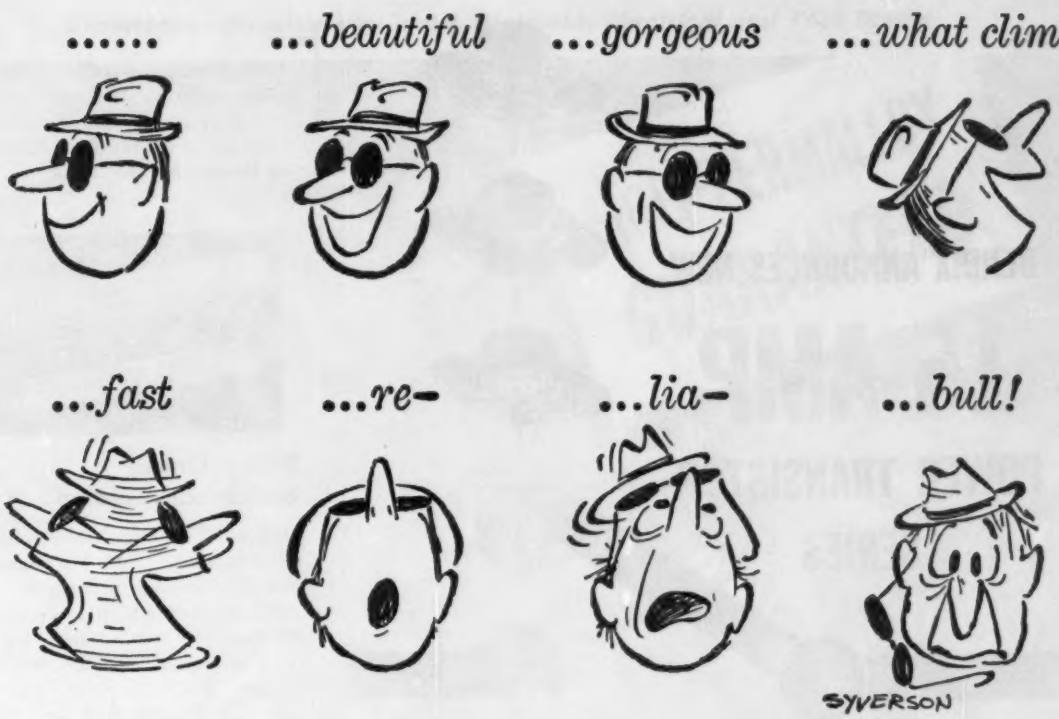
THOMAS A. EDISON INDUSTRIES, McGraw-Edison Co., has announced a new electromechanical assembly designed to form a part of a missile integrating system. The integrating servo with rate feedback consists of a size 8 servo motor generator, precision potentiometer and a high-ratio gear reducer. **Circle 209 on Reader Service Card.**

## Tubular Capacitors ceramic case

AXEL BROS., INC., 134-20 Jamaica Ave., Jamaica 18, N. Y., has available h-v ceramic case tubular capacitors with extremely high insulation resistance, high humidity resistance, low power factor and low temperature coefficient. They are constructed using quality capacitor tissue and polyester film, impregnated with a stable purified silicone fluid. The hermetic-seal steatite housing cuts the weight and size of finished capacitors to a fraction of that of comparable metal-can capacitors. **Circle 210 on Reader Service Card.**

## Sweep Generator covers 100 kc to 20 mc

MARCONI INSTRUMENTS, 111 Cedar Lane, Englewood, N. J. Model




High-flying, high-cost investments deserve protection. The best policy is pre-flight testing that checks out vital avionic systems on the ground... insures expensive ventures into space. Look to INET for the precise electrical power you can wheel right out on the flight line... in a single, custom-made package.

# NEXT TIME...LOOK TO INET FOR PROVEN RELIABILITY

This INET unit was tailor-made for one of the latest Air Force Fighter-Interceptors. In seconds it brings to life all the avionic systems the plane will carry aloft. The unit provides eight power outputs for separately generated 1,600-cycle, 400-cycle, and DC power at closely regulated voltages for power supply, instrumentation checkout, and equipment testing.

▶ Engineers desiring a special reprint of the above cartoon should write to: "FLAME-OUT" c/o Inet Division of Leach.

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## BENDIX ANNOUNCES NEW

# 15-AMP

## POWER TRANSISTOR SERIES

Now in production by Bendix are eight new 15-ampere power transistors capable of switching up to 1000 watts —and you can get immediate delivery on all eight types.

New in design, the transistors have a higher gain and flatter beta curve. The series are categorized in gain and voltage breakdown to provide optimum matching and to eliminate burn-out. Straight pins or flying leads can be supplied on request.

Ask for complete details on this new Bendix transistor series . . . and on the complete Bendix line of power rectifiers and power transistors. Write SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY.

| Current Gain at 10 Adc | Collector-to-Emitter Voltage Rating* | | | |
|---|---|---|---|---|
| | 30 | 40 | 70 | 80 |
| 20-60 | 2N1031 | 2N1031A | 2N1031B | 2N1031C |
| 50-100 | 2N1032 | 2N1032A | 2N1032B | 2N1032C |

*Comparable collector-to-base breakdowns range 20-50% higher.

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**1099 sweep generator is a precision video instrument, covering 100 kc to 20 mc, and includes both 1 mc and 5 mc markers. Circle 211 on Reader Service Card.**

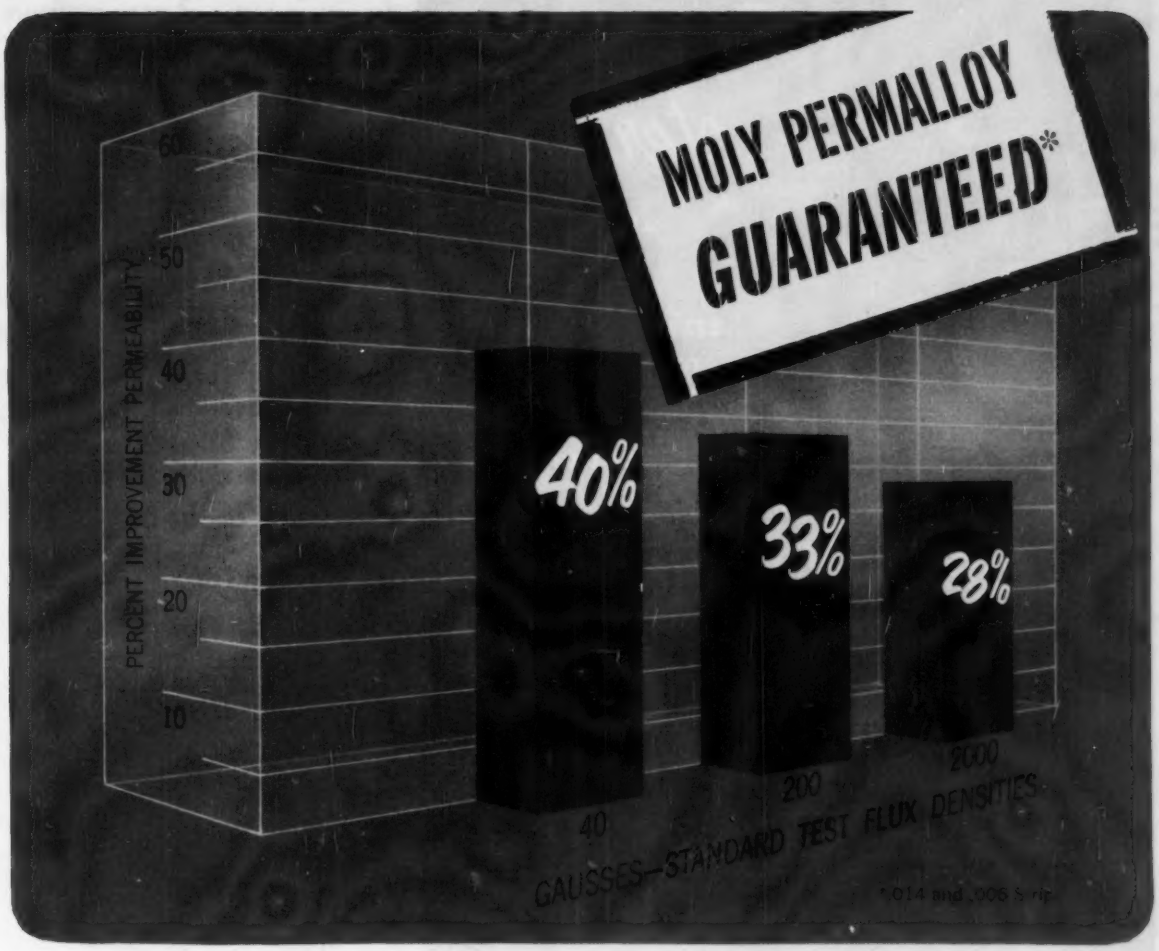
### Delay Lines hermetically sealed

DIGITRONICS CORP., Albertson Ave., Albertson, L. I., N. Y., announces new continuously variable delay lines each of which is completely hermetically sealed and features infinite resolution. The new delay ranges available are from 0.18 μsec to 0.22 μsec, 0.23 μsec to 0.27 μsec, 0.28 μsec to 0.32 μsec, 0.33 μsec to 0.37 μsec; 0.48 μsec to 0.52 μsec and 0.58 μsec to 0.62 μsec. Characteristic impedance is 250 ohms; however higher impedances are readily available. Other characteristics are a rise time of 0.06 μsec and a maximum attenuation of 1.0 db. **Circle 212 on Reader Service Card.**

### Coax Connectors thread coupled

RF FITTINGS, INC., 702 Beacon St., Boston, Mass. The TM series of thread coupled, miniature, lightweight coax connectors yield low vswr at high frequencies and are designed so that electrical noise is eliminated, permitting the reception of weak, low level signals. They are matched electrically for 50 ohm impedance and some designs are available for 70 and 93 ohm cables. The series will withstand 500 v rms, which exceeds the

***Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels***

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Molybdenum Permalloy nickel-iron strip is now available from Allegheny Ludlum with *guaranteed* permeability values. And the new guarantees are much higher than the old typical values. This exceptionally high quality means absolute uniformity for the user—new consistency and predictability for magnetic core performance.

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Another plus in dealing with Allegheny Ludlum is the operation of complete lamination fabrication and heat treatment facilities. A-L's years of experience in producing quality laminations result in practical know-how in solving problems common to core materials.

This working knowledge is available to all. Give us a call for prompt technical assistance on *any* problem involving electrical steels, laminations, or magnetic materials. Write for more information on A-L Moly Permalloy. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. E-13.***

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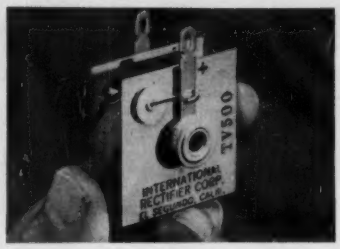
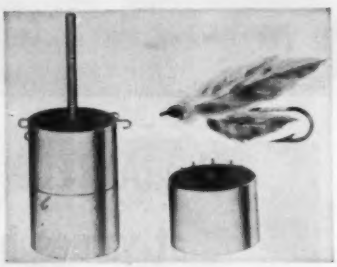
NOTE: Data Sheets on request

voltage rating of many miniature cables. **Circle 213 on Reader Service Card.**




## Silicon Rectifier rated to 750 ma

INTERNATIONAL RECTIFIER CORP., 1521 E. Grand Ave., El Segundo, Calif. The Unistac TV-500 silicon radio-tv rectifier now features forward current ratings up to 750 ma. Featuring eyelet construction, this unit eliminates the need for special sockets, drilling or conversion kits. The Unistac employs a silicon diode mounted on a finned heat exchanger designed to assure maximum convection cooling. **Circle 214 on Reader Service Card.**



## Toroidal Inductor temperature-stable

ARNOLD MAGNETICS CORP., 4613 W. Jefferson Blvd., Los Angeles 16, Calif. A new small-size toroidal inductor features optimum temperature stability across the military temperature environment range of −55 to +71 C. Inductance can be as little as ±0.25 percent change in this range. Unit uses a stabilized core, and is fully encapsulated with special materials to acquire the desired temperature stability. Inductance values range from 0.1 mh to 17 henries, and useful frequency ranges from 60 cps to 500

**(Continued on p 96)**

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| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
| 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |
| 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 |
| 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 |
| 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 |
| 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 |

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| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
| 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |
| 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 |
| 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 |
| 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 |
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# 140 KMC

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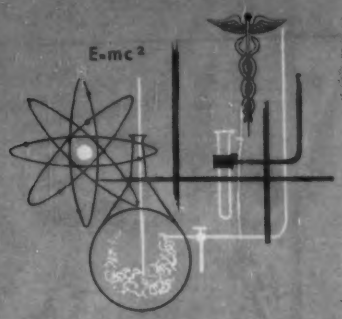
*–it works–it's accurate–it's available*




These millimeter wave units can greatly enlarge your scope of microwave activity. Research previously considered impractical at 140 KMC can now be carried on successfully.

De Mornay-Bonardi manufactures cavity wavemeters, crystal multipliers, crystal mounts, E-H tuners, and standing wave detectors specifically for use at 140 KMC. They work—we've been using these units effectively in our own laboratories for developing other items. These instruments are accurate—functionally as accurate as De Mornay-Bonardi equipment used at 90 KMC. You can order these units now—we're currently filling orders on 140 KMC instruments.

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STANDING WAVE DETECTORS

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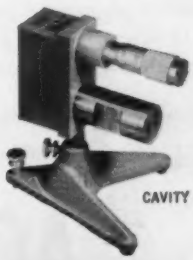
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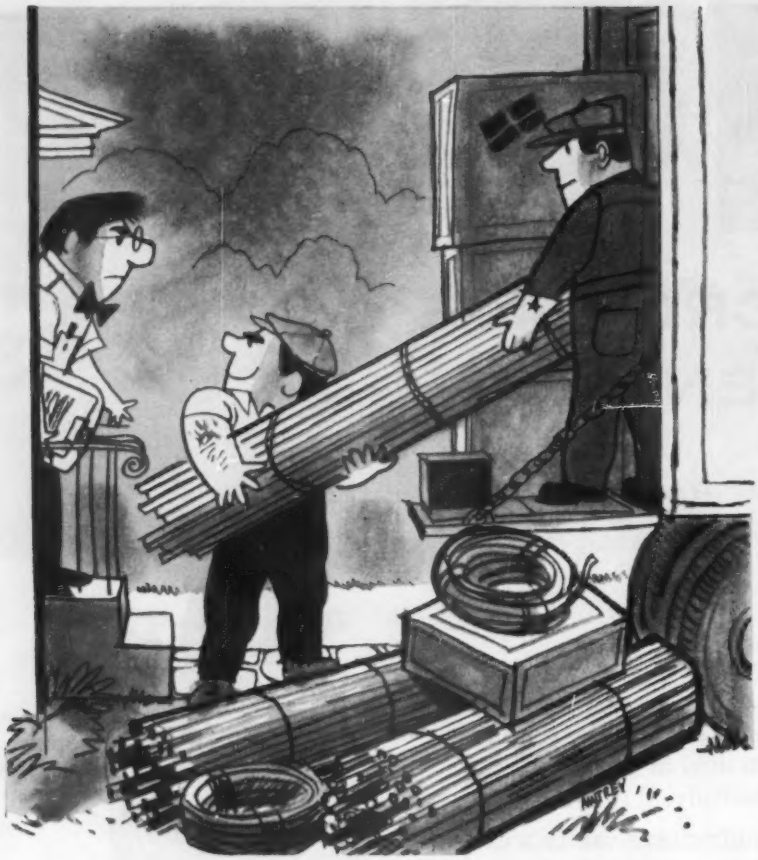


# plan ahead!

To be *really* sure of getting your pot deliveries on time, you *could* assemble your own! But just when you're counting on sub-contractors to deliver the necessary parts — you *might* find they're tied-up on someone *else's* job! So if you *must* be sure, lay in a good supply of raw materials in quantity lots — metals, glass, wire, plastics, bearings — the works!

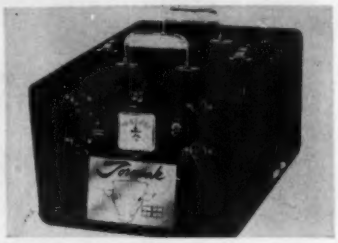
But before you load up the living-room with bar stock, check with Ace. You'll find, to your relief, that Ace abundantly warehouses all their own raw materials — just for the express purpose of being able to *make* everything they need — when it's needed, for controlled delivery! So if *delivery* of precision pots is a prime consideration, talk to the company that does its *own* sub-assembly manufacture — see your Acerep!

*From raw materials to completed pot — within the plant — our servo-mount A.I.A. size ⅞" ACEPOT®. As with all the others, from ½" to 6".*

**ACE ELECTRONICS ASSOCIATES, INC.**
99 Dover Street, Somerville 44, Mass.
SOmerset 6-5130 TMX SMVL 181 West. Union WUX

Acepot® Acetrim® Aceset® Aceohm® *Reg. Appl. for


kc. The units are designed for printed circuit boards, or stacking on a single screw for chassis mounting. **Circle 215 on Reader Service Card.**



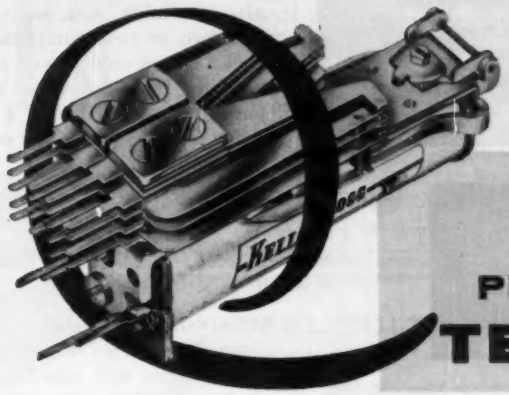
## Power Pack
## reliable, rugged

FRANCIS BROS., 446 C St., Tustin, Calif. Model P14-65 ToroPak is engineered to supply d-c or a-c power where none exists or for emergencies during power failures. The units will find wide usage in military, industrial, marine, civilian and civilian defense applications. They supply 110 v, 60 cps single phase power up to 200 w continuous output for eight hours or more. They will also provide 12 v d-c current for an extended period. Units can then be recharged with a-c or d-c current in several hours. **Circle 216 on Reader Service Card.**

## Memory System
## random access

RESE ENGINEERING, INC., 731 Arch St., Philadelphia 6, Pa. Model 3122 is a random access memory system for the data processing industry. With access time of 12 μsec, it has a capacity of 512 8 binary digit characters, with random access for both writing and reading. Read and write access cycles may be arbitrarily mixed, and synchronous internal timing or synchronous or asynchronous external

# KELLOGG'S NEW type "AK" telephone type direct current RELAY with



## *TAPER TAB
## STRAIGHT TAB
## PRINTED CIRCUIT TERMINALS

## for industrial applications

*Another FIRST for Kellogg in the relay field*
*Three Terminals...in one design*

The "AK" relay is highly sensitive, adaptable for marginal operation and provides fast closing and opening of a maximum number of circuits. Its long coil construction permits the use of high resistance coils and it may be engineered to operate on as little as .002 amps. Delay in the opening and closing times may be provided through use of copper-slugged coils. Time delay relays are designated as Type AKSO (slow operate) and Type AKSR (slow release).

Inquiries are invited. Send for a free catalog on relays and other components manufactured by Kellogg. Kellogg Switchboard and Supply Company, 6650 South Cicero Avenue, Chicago 38, Illinois. Division of International Telephone and Telegraph Corporation.

**COIL CHARACTERISTICS**

Operating Voltage—Up to 230 volts D.C.
Single or double wound

**CONTACT ASSEMBLY**

Single or double pile-up
Forms "A" to "E"
14 springs maximum in each pile-up
Alternative: Single or double microswitch
Standard terminals also available

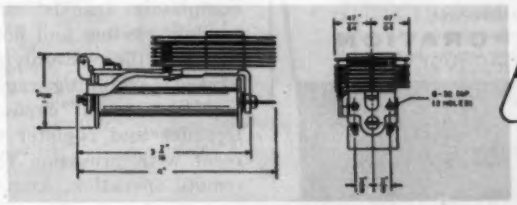
**OPERATE AND RELEASE TIME**

.002 sec. minimum operate
.100 sec. maximum operate delay
.400 sec. maximum release delay

**WEIGHT**

8—12 oz. net (approx.)

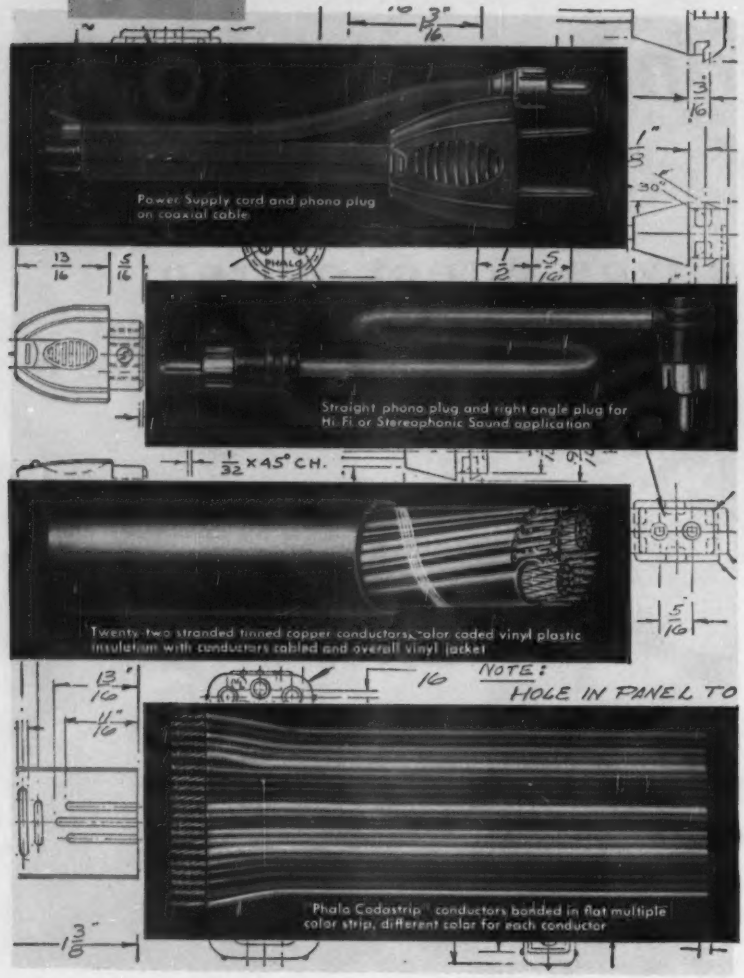
**Replacement when soldering is necessary.*



KELLOGG

*Manufacturers of:*
**• Relays • Hermetically sealed relays**
**• Switches • Solenoids**

PHALO engineered...


Power Supply cord and phono plug on coaxial cable
Straight phono plug and right angle plug for Hi-Fi or Stereophonic Sound application
Twenty-two stranded tinned copper conductors, color coded vinyl plastic insulation with conductors cabled and overall vinyl jacket
NOTE: HOLE IN PANEL TO
Phalo Codastrip conductors bonded in flat multiple color strip, different color for each conductor

*to fill the needs you specify...*

Recognized engineering diversity. . . new, greatly enlarged capacity . . . new, maximum efficiency of production. Very simply, that is Phalo 1959.

Producing For All Industry From The Most Modern Plant In The Wire and Cable Industry!

*Complete Product Data and Sales Service Information On Request*

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PHALO
530 BOSTON TURNPIKE
PLASTICS CORPORATION
SHREWSBURY, MASSACHUSETTS

*Representatives in Leading Cities Throughout The U. S. A.*

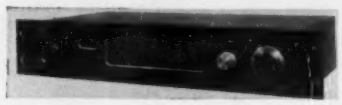

timing may be employed, depending on requirements. **Circle 217 on Reader Service Card.**

## L-V Power Supplies closely regulated

QUAN-TECH LABORATORIES, Morristown, N. J., offers a series of low voltage power supplies closely regulated, designed for general laboratory applications. They are also available rack mounted with one, two, or three units in a 19-in. rack. Three models are available, ranging from 0-8 v d-c at 2 amperes to 0-30 v d-c at ½ ampere. Price is $175. **Circle 218 on Reader Service Card.**

## A-C Potentiometer miniaturized

PERKIN-ELMER CORP., Norwalk, Conn. The series 4 Vernistat potentiometers are size 11 components (1.062-in. diameter), and weigh only two oz. They are available with maximum output impedances of 200, 100, and 40 ohms, combined with high input impedance, and low output quadrature. Minimum output voltage increment (resolution) is 0.01 percent and terminal linearity is 0.05 percent. **Circle 219 on Reader Service Card.**

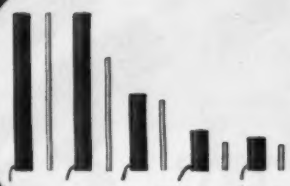


## Scaler transistorized

RADIATION INSTRUMENT DEVELOPMENT LABORATORY, INC., 5737 South Halsted St., Chicago 21, Ill. Model 49-21 transistorized scaler utilizes completely transistorized digital readout system and non-overloading amplifier. Resolving time is ½ μsec (excluding register) with maximum count capacity of $10^9$. Decades and register electrically reset with provision for local or remote operation. Amplifier sensitivity is 1 mv with gain of 1,000. Accessory transistorized pream-

# SANBORN *Transducers*

## FOR LINEAR MEASUREMENTS...



### DISPLACEMENT

**LINEARSYN Differential Transformers**

Six series of Sanborn Linearsyns — three of the shielded type, three unshielded — are available, with five models in each series. Linearity is better than 1% of full scale output in all models. Temperature range is from −50° to 205°F. Special design features include coil assemblies hermetically sealed in epoxy, laminated phenolic jackets (unshielded types) or heavy plated steel jackets (shielded types), improved lead wire strain relief, high permeability alloy cores. Models with axial leads are also available on special order. Within each series all models have identical diameters, tap sizes, lead wires; only the lengths of coil assemblies and cores vary.

**Typical Linearsyn Characteristics**

| Series* (Unshielded) | (Shielded) | Strokes* (±Inches) | Freq. Ranges | Sensitivities* (Volts/inch per volt of excitation at std. carrier freq.) |
|---|---|---|---|---|
| 575DT | 585DT | .050 - 1.00 | 400 cps - 10 kc | .56 - 3.70 |
| 576DT | 586DT | .050 - 1.00 | 60 cps - 400 cps | .70 - .90 |
| 590DT | 595DT | .005 - .100 | 400 cps - 20 kc | 1.60 - 2.60 |

*Maximum and minimum values available within each series; data on individual models on request.

### VELOCITY

**LVsyn Velocity Transducers**

LVsyn pickups may be used to measure *linear velocity* directly, *displacement* with a simple integrating circuit, or *acceleration* with a differentiating circuit. There are twenty-four models, all self-generating with shielded cylindrical coil assemblies and high coercive force permanent magnets. Twelve models use regular magnet cores; twelve have *non-breakable* magnet cores. Characteristics of the two groups are the same except for output sensitivity, core length and weight. Features include high sensitivity, single-ended or push-pull output, accurate and stable calibration, unlimited resolution, wide range of sensitivities and sizes, temperature range of −50° to 200°F. They can be immersed in hydraulic fluid. No mechanical connection between coil and core permits low friction level. End stops or displacement limits not needed; undamaged if limits are extended.

**Typical LVsyn Characteristics**

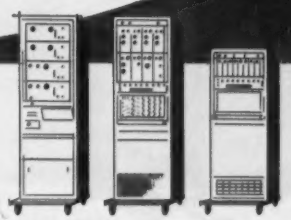
| Model | Displacement Nominal Working Range (Inches) | Displacement Maximum Usable Stroke (Inches) | Electrical Characteristics Voltage Output mv/inch | Total Impedance Series Connection R ohms | L henrys |
|---|---|---|---|---|---|
| 3LVA5* | 0.50 | 1.30 | 120 | 2,000 | 0.085 |
| 6LV2* | 2.0 | 3.4 | 500 | 19,000 | 2.4 |
| 6LV2-N | 2.0 | 3.4 | 250 | 19,000 | 2.4 |
| 7LV9* | 9.0 | 11.0 | 350 | 17,000 | 2.8 |

*Four of the twenty-four models available, selected to show minimum, approximate mid-range and maximum working ranges as well as the difference in sensitivity between a regular magnet core model (6LV2) and a non-breakable magnet core model (6LV2-N).

### NEW!

**COMPLETE DISPLACEMENT TRANSDUCER**

"Probe" style, uses differential transformer. With cable and adapter for connection to Sanborn 150, 350 Series Carrier Amplifiers. Stroke ±0.070", high sensitivity, linearity 0.5%, infinite resolution, contact pressure as low as 10 grams. Stainless steel body, carbide tipped contact rod, jeweled bearings. Two models: 580—plug-in cable, flange mounting; 581—miniature, integral cable.



**for MULTI-CHANNEL RECORDING**

Sanborn direct writing systems now include 1- to 8-channel "150" Series, with a choice of 12 plug-in Preamplifiers; new single-cabinet, compact 6- and 8-channel "350" and "850" Series with interchangeable Preamplifiers, flush-front recorder with electrical pushbutton chart speed control and transistorized Power Amplifiers, and numerous features for high reliability and operating convenience.

For complete facts, call your local Sanborn Industrial Sales-Engineering Representative or write the Industrial Division in Waltham.

(All data subject to change without notice)

## SANBORN COMPANY

Industrial Division

175 Wyman Street, Waltham 54, Mass.

RD INSTRUMENTS
FOR RESEARCH AND DEVELOPMENT

MODEL 1715

**NEW SQUARE WAVE GENERATOR**

Frequency range of 1 cps to 1 megacycle.

Rise time of 0.02 microseconds.

Highly stable.

Voltage regulated.

New centerline construction improves reliability.

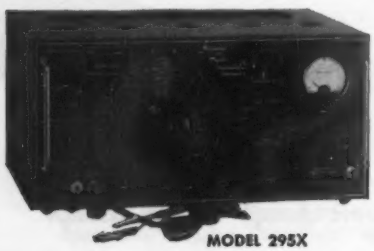
**$265**

**SINE-WAVE SQUARE-WAVE GENERATOR**

Covers a wide frequency range of 20 cps to 1 megacycle—both sine-wave and square-wave. Sine wave total harmonic distortion is below 1%. Square wave rise time is less than 0.1 microseconds.

**$495**

MODEL 710



MODEL 295X

**MICROVOLT and CRYSTAL CONTROLLED GENERATOR**

Continuous frequency coverage from 125 kilocycles to 175 megacycles on fundamentals. Direct reading. Vernier tuning. Metered output from 0.1 to 100,000 microvolts—No external pad required.

Crystal controlled RF oscillator 400 kilocycles to 20 megacycles—to 250 megacycles on harmonics.

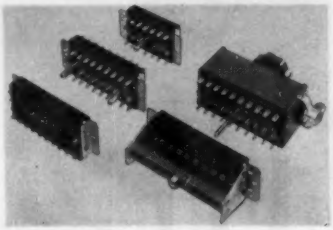
**$497**

A demonstration or technical literature is available at your request

RD INSTRUMENTS
FOR RESEARCH AND DEVELOPMENT

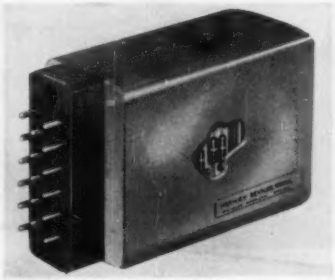
The Hickok Electrical Instrument Company • 10514 Dupont Ave. • Cleveland 8, Ohio

plifiers are available to match low input impedance of amplifier to any type of detector. **Circle 220 on Reader Service Card.**



## Connectors two new types

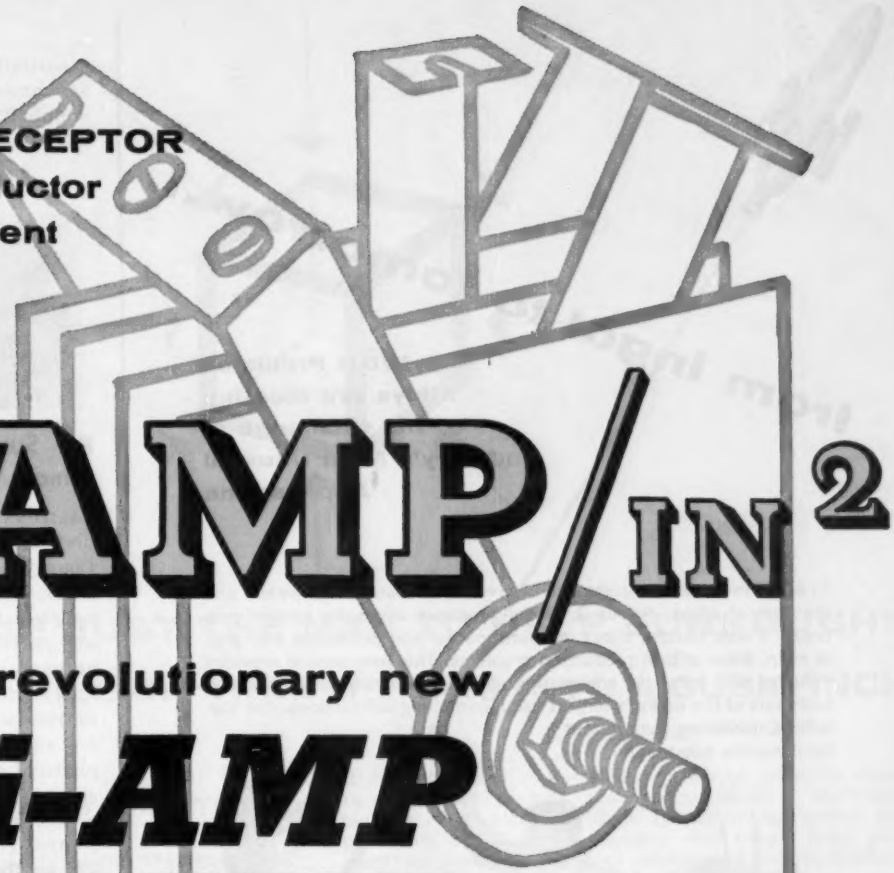
ELCO CORP., M Street below Erie Ave., Philadelphia 24, Pa., has added to its Varicon family the guide pin and the screw types. In the former a molded male and female double tier section provides a hole at the center to mount a sturdy guide pin or to act as mating guide hole. In the latter type, a spindle, operated by a knob on top of the connector housing, screws into a nut, located in a bridge behind the mating member. **Circle 221 on Reader Service Card.**



## Telemetry Keyer subminiature

ROTARY DEVICES CORP., 30 Jay St., Englewood, N. J., has developed a new subminiature pulse width modulator or keyer for use in missile or other telemetry systems. The keyer converts an amplitude modulated pulse sequence to a pulse series of constant amplitude and variable width. The output pulses are suitable for modulating a subcarrier oscillator or r-f transmitter. The keyer is characterized by low linearity error, relative in-

another
RADIO RECEPTOR
semiconductor
achievement



# 3* AMP/IN²

with the revolutionary new

# Tri-AMP

## SELENIUM RECTIFIER

***300% higher current density***

- life expectancy of 100,000 hours.
- 26 volt cells — lower forward voltage drop.
- no parallel devices for voltage division.
- no series devices for load sharing.

THE DIFFERENCE AT A GLANCE!

| New Tri-AMP 3-phase Bridge | | Standard Type 3-phase Bridge | |
|---|---|---|---|
| Dimensions | Amp. | Dimensions | Amp. |
| 4" x 4" Fan Cooled | 54 | 4" x 4" Fan Cooled | 16.8 |
| 4" x 4" Convection Cooled | 18 | 4" x 4" Convection Cooled | 6.7 |

*Now you'll understand why conventional selenium rectifiers are now obsolete!*

Not just a variation of standard selenium rectifiers — TRI-AMP is a *new* selenium semiconductor with far greater reliability, operating at *three times* the current density of standard stacks. It has the overvoltage and overcurrent advantages of selenium, which means there is no need for the expensive and elaborate protective devices so necessary when using other semiconductors.

Our Radio Receptor plant, working with unique equipment developed by Siemens of West Germany, is now producing TRI-AMP selenium semiconductors for immediate delivery. Please request full information from Section E-1R.

* General Instrument Corporation also includes Automatic Manufacturing Division, F. W. Sickles Division, Micamold Electronics Manufacturing Corporation (subsidiary)

GENERAL INSTRUMENT
SEMICONDUCTORS

semiconductor division
**RADIO RECEPTOR COMPANY, INC.**
*Subsidiary of General Instrument Corporation*
240 Wythe Avenue, Brooklyn 11, N. Y.

GENERAL INSTRUMENT DISTRIBUTORS: *Baltimore:* D & H Distributing Co. • *Chicago:* Merquip Co. • *Cleveland:* Pioneer Electronic Supply • *Los Angeles:* Valley Electronics Supply Co., Burbank • *Milwaukee:* Radio Parts Co., Inc. • *New York City:* Hudson Radio & Television Corp., Sun Radio & Electronic Co. *Philadelphia:* Herbach & Rademan, Inc. • *San Francisco:* Pacific Wholesale Co. • *Seattle:* Seattle Radio Supply • *Tulsa:* Oil Capitol Electronics

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Precision alloys for all applications including—

| | |
|---|---|
| Nickel Chrome | Filament and Grid |
| Heat Resisting | Beryllium Copper |
| Low Temperature Coefficient | Stainless Steel |
| High Temperature Coefficient | Pure Nickel |
| Glass Sealing | Monel* |

—available in wire, rod, ribbon and strip

—with insulations of enamel, Formvar, liquid Nylon, cotton, silk, Nylon and fibre glass

*T.M. International Nickel Co.

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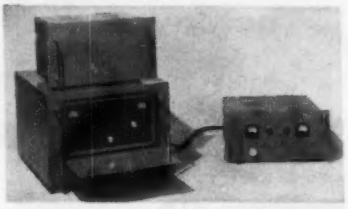
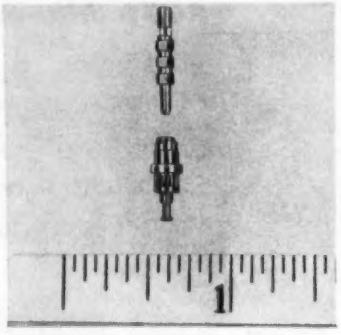
sensitivity to phasing of input synchronizing pulse and overall simplicity and reliability. **Circle 222 on Reader Service Card.**



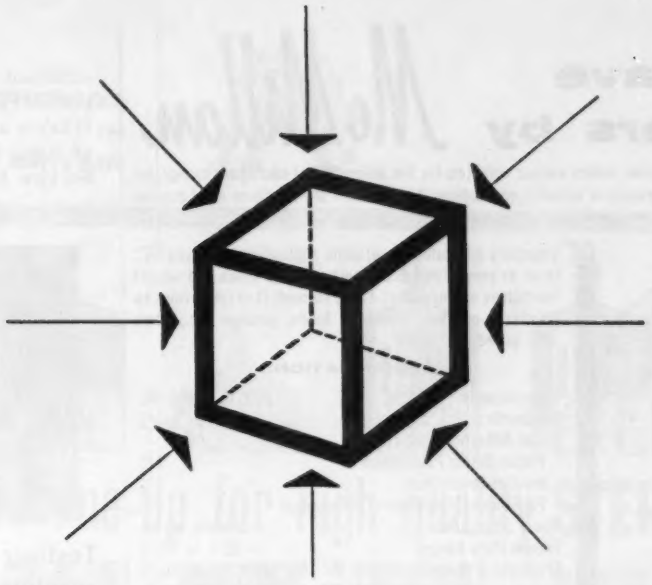
## R-F Supplies
### remote tuning

CALIFORNIA TECHNICAL INDUSTRIES division of Textron Inc., 1421 Old County Road, Belmont, Calif. A series of tunable magnetron r-f supplies from S through $K_a$ bands are particularly suited for use on antenna pattern ranges and other applications where a pulsed magnetron source is required. Each r-f supply is divided into three physical units: a modulator, an r-f source, and an optional remote control unit that permits complete control from any location. **Circle 223 on Reader Service Card.**



## Panel Jack
### for tight patch work

CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass. The 2515 jack is designed for quick, tight patch work. It assures perfect electrical connections because permanent gripping power is maintained by a specially designed compression spring used with a floating key. It is provided with a solder terminal for convenient wiring. The jack may be



# YOU MAY BE JUST THE MAN TO HELP BURROUGHS SQUEEZE A MILLION TRANSISTORS INTO A CUBIC INCH

**OR EXPLORE FIELDS LIKE THESE:**

- Statistical approaches to physiological processes
- Electro-chemical phenomena
- Radiation effects
- Plasma physics
- Magneto hydro-dynamics
- Electro-luminescence
- Cryogenics
- Superconductivity
- Semi-conductors
- And a lot of others

Right now—today at Burroughs: plenty of room for exceptional engineers to help create the *successors* to Burroughs' big line of advanced electronic and electro-mechanical data processing equipment. Equipment that ranges from giant electronic computer systems to automatic accounting machines and more.

We need men who can help us put the functional equivalent of a million transistors into a cubic inch of material. Or men who can help us produce equally advanced results in fields like those mentioned at the left.

Men who can thrive on working without strait jackets.

Men who can get the most out of our heavily budgeted research facilities.

Men who can welcome the security of our *cohesive* research programs. How cohesive? Because their common aim is to improve information processing for both commercial and military use. How do the programs offer security? Because their cohesiveness allows you to shift readily from one to another without learning a new technology.

We want men whose creativity will help us double our $300 million yearly sales rate fast—and then redouble it even faster.

Men who are frankly interested in increased responsibility. In swift promotion in careers that offer a wide choice of location. And, yes, in money.

Are you as outstanding as these opportunities? Then outline your education and experience as briefly or fully as you wish, name the field you'd like to help us explore, and get that information to A. L. Suzio, Administrator, Corporate Placement Services, Dept. 101, Burroughs Corporation, Detroit 32, Mich.

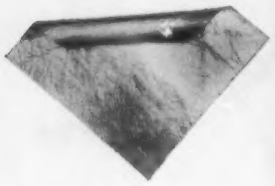
Burroughs

## Burroughs Corporation

"NEW DIMENSIONS / IN ELECTRONICS AND DATA PROCESSING SYSTEMS"

# microwave absorbers by McMillan

McMillan Industrial Corporation makes various materials for the absorption of microwave energy, for indoor or outdoor use and for ground or airborne applications. Listed below are the three most popular absorbers, their typical applications, specifications and characteristics.

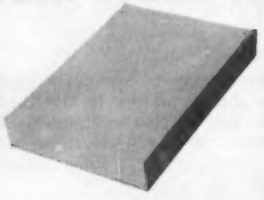


**TYPE "T"**
THIN — FLEXIBLE

Especially adaptable for airborne applications, the type "T" is an extremely versatile absorber where space and weight limitations are essential. Easily formed, it is impervious to effects of moisture, hydraulic fluids, gasoline etc., when edge sealed.

**SPECIFICATIONS**

| | |
|---|---|
| Frequencies: | 2500 to 35,000 MC. |
| Bandwidth: | ±3% |
| Power Reflection Coefficient: | |
| Perpendicular Polarization | 1% |
| Parallel Polarization | 2% |
| Perpendicular & Parallel Polarization | 2% |
| Power Dissipation: | 2 watts/sq. in. |
| Temperature Range: | −62°F to 172°F |
| Thickness & Weight: | at 9375 MC., 3/16" thick, 4.7 oz./sq. ft. at 5400 MC., 1/4" thick, 5.7 oz./sq. ft. |
| Standard Sheet Size: | 18" x 36" |



**TYPE "BL" & "BH"**
PERMANENT — LIGHTWEIGHT

Two stable absorbers whose high performance and long life is not affected by moisture, humidity and dust. Type "BL" is fine for walls, ceilings and test panels. Type "BH" is excellent for test room floors and outdoor installations, as its high absorption characteristics are unchanged when it is walked on.

**SPECIFICATIONS**

| | |
|---|---|
| Frequency range: | 1000 to 35,000 MC. |
| Power reflection coefficient: | 0.4% at 24,000 MC. |
| (perpendicular and/or parallel | 1.0% at 9,400 MC. |
| polarization) | 2.0% at 5,400 MC. |
| Power dissipation: | 2 watts/sq. in. |
| Temperature range: | (type "BL") −62°F to 155°F |
| | (type "BH") −62°F to 175°F |
| Standard block size: | 2" or 4" thick, 4' long, 1' wide |
| Weight: | (type "BL") .5 lbs./sq. ft. |
| | (type "BH") .7 lbs./sq. ft. |

**TYPE "BL-48"**
BROADBANDED — PERMANENT

Recommended for use in the low frequency range where permanent attenuation characteristics are required, for both indoor and outdoor applications.

**SPECIFICATIONS**

| | |
|---|---|
| Frequency range: | 40 to 35,000 MC. |
| Power reflection coefficient: | 2½% |
| (perpendicular and /or parallel polarization) | |
| Power Dissipation: | 2 watts /sq. in. |
| Size: | Base — 1' x 2' |
| | Height — 48" |
| Weight: | 5 lbs. /sq. ft. |
| Temperature range: | −62°F to 155°F |

Also available — Type "H" Hair Mat Absorbers in thicknesses from 1" to 8" for frequencies from 500 to 35,000 MC

McMillan

**McMILLAN LABORATORY, INCORPORATED**
Brownville Avenue • Ipswich, Massachusetts


obtained in shank lengths for panels varying from $\frac{3}{32}$ in. to $\frac{7}{16}$ in. It takes a plug with a pin diameter of 0.062 in. **Circle 224 on Reader Service Card.**

## Testing Chambers simulate −150 to +400 F

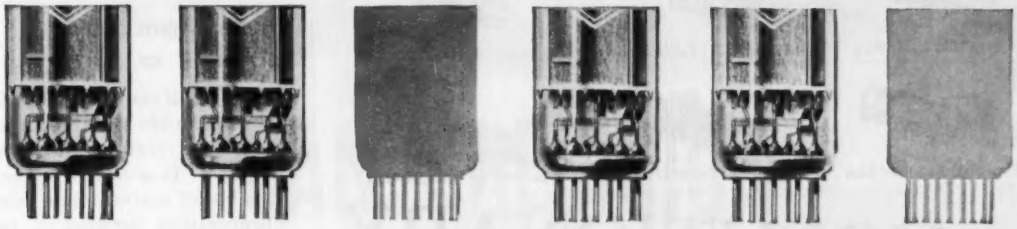
INTERNATIONAL RADIANT CORP., 111 New York Ave., Westbury, L. I., N. Y., has developed a new series of ThermaLine testing chambers for use in the simulation of ultra low and high temperatures in ranges from −150 F to +400 F as well as high altitudes and precision humidity. Among their functions are: testing anything from component parts to complete assemblies; for tests involving military specification standards; as a supplement to heat treating and shrinking of metal parts; basic and fundamental research in government institutions, schools and colleges as well as industry. **Circle 225 on Reader Service Card.**

## Decimal Converter binary to binary

AERONCA MFG. CORP., Baltimore 28, Md., has available a new binary to binary coded decimal converter. Unit performs the difficult translation of the pure binary code to the binary (coded) decimal code. Relays used in the equipment are of the miniature type, equipped with 24 v 300 ohm coils and a rated pull-in time of 2 millisec. Conversion time depends upon the time required for the relays to set up through the longest route in the translator. An input for each binary bit should be provided and sustained for a period of 10 millisec. The input relays in the

**ELECTRONICS IN BRITAIN**

# complete tube line-up for high quality **STEREO SOUND**



## ECL82* (6BM8)

**TYPICAL OPERATING CONDITIONS**

| | | |
|---|---|---|
| **Single valve class 'A'** | | |
| $V_a$ | 250 | V |
| $V_{g2(b)}$ | 250 | V |
| † $R_{g2}$ | 2.2 | kΩ |
| $I_{a(o)}$ | 28 | mA |
| $I_{g2(o)}$ | 5.5 | mA |
| $I_{g2}$ (max. sig.) | 10.5 | mA |
| $V_{g1}$ | −22.5 | V |
| $R_k$ | 680 | Ω |
| $V_{in(r.m.s.)}$ ($P_{out}$ = 50mW) | 780 | mV |
| $R_a$ | 9.0 | kΩ |
| $V_{in(r.m.s.}$ | 9.5 | V |
| $P_{out}$ | 3.4 | W |
| $D_{tot}$ | 10 | % |
| **Two valves in class 'AB' push-pull** | | |
| $V_a$ | 250 | V |
| $V_{g2(b)}$ | 250 | V |
| †† $R_{g2}$ | 2.7 | kΩ |
| $I_{a(o)}$ | 2 x 21.5 | mA |
| $I_a$ (max. sig.) | 2 x 27.5 | mA |
| $I_{g2(o)}$ | 2 x 4.2 | mA |
| $I_{g2}$ (max. sig.) | 2 x 9.2 | mA |
| ††† $R_k$ | 390 | Ω |
| $V_{in(g1-g1)r.m.s.}$ | 38 | V |
| $R_{a-a}$ | 10 | kΩ |
| $P_{out}$ | 9.0 | W |
| $D_{tot}$ | 5.0 | % |

†Undecoupled screen-grid resistor.
††Common screen-grid resistor undecoupled.
†††Common cathode bias resistor.

* **UCL82** which has the same characteristics as the ECL82 is available for AC/DC operation.

The introduction of the Mullard ECL82 triode pentode means that you can now build a complete high quality stereo sound equipment with ONLY 6 TUBES, including rectifier. Used with a specially developed Mullard circuit, two pairs of ECL82 tubes, one ECC83 voltage amplifier and one EZ81 rectifier will provide two complete ultralinear push-pull channels each giving an output of 7W. at 0.3% total distortion. Write at once for full details of tubes *and* circuit to either of the distributors listed below.

**Supplies available from: In the U.S.A.**
*International Electronics Corporation*
*Dept. 000, 81 Spring Street, N.Y.12,*
*New York, U.S.A.*

**In Canada**
*Rogers Electronic Tubes & Components*
*Dept. 000, 116 Vanderhoof Avenue,*
*Toronto 17, Ontario, Canada.*

# Mullard
## ELECTRONIC TUBES used throughout the world

*"Mullard" is the Trade Mark of Mullard Limited and is registered in most of the principal countries of the world.*

**MULLARD OVERSEAS LTD., MULLARD HOUSE, TORRINGTON PLACE, LONDON, ENGLAND**
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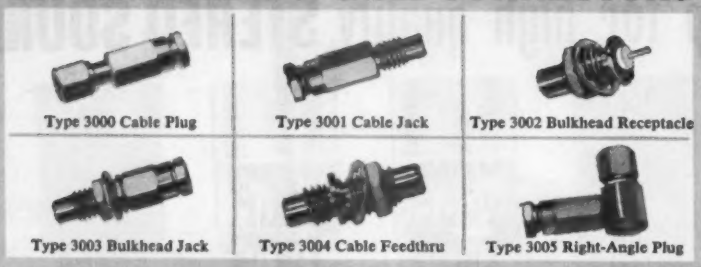
CONHEX*

Pat. Pend.

SUB-MINIATURE R. F. CABLE **CONNECTORS**



Type 3000 Cable Plug | Type 3001 Cable Jack | Type 3002 Bulkhead Receptacle

Type 3003 Bulkhead Jack | Type 3004 Cable Feedthru | Type 3005 Right-Angle Plug

REVOLUTIONARY

*because...*

- **EASE OF ASSEMBLY:** In factory, shop, lab, field. No special tools required.
- **INCREASED PULL-OUT RESISTANCE:** Cable-clamping construction withstands over 20-lb. strain.
- **CAPTIVATED CONTACTS:** Insure proper engagement with mating parts. Especially important with short cable lengths.

The result of a decade and a half of intense specialization, "ConheX" connectors set brand new standards. Yes, *revolutionary* is the word.

In 50-ohm impedance size as shown, including the *unique* right-angle plug. 75- and 95-ohm sizes to follow. Designed for use with latest MIL sub-miniature cables. Suitable for use at microwave frequencies. Interchangeable with but *superior* to existing connectors of corresponding types.

Parts of machined brass except for female contacts of heat-treated beryllium copper. Genuine gold plating (not just gold flash) over copper. Insulators of Teflon.

JUST TRY "CONHEX"! Write for literature. If you are a design or specification engineer, write on business letterhead for free sample. Make your own comparisons and tests. And let us quote!

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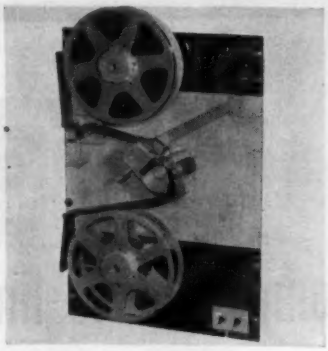
converter will then lock up, and readout signals can be obtained. **Circle 226 on Reader Service Card.**



## Tape Transports portable or fixed

D. G. C. HARE CO., New Canaan, Conn. The 460 series of tape transports are high performance, inherently tape-synchronous units capable of maintaining exact synchronization between a recorded and a fixed reference frequency, over wide variations of record speed and line variations. The speed control system is both rapid acting and completely damped. This feature allows the exact replay of tapes from uncontrolled recorders, such as those used in some missiles and aircraft, requiring only that the recorded tape have a fixed frequency reference. **Circle 227 on Reader Service Card.**

## Silicon Transistors two new types

TRANSITRON ELECTRONIC CORP., 168 Albion St., Wakefield, Mass., Specified at typically high noise frequencies (from audio down to 1 cps), the ST1050 *npn* silicon transistor has equivalent input noise voltage of about 1 $\mu$v rms when used with low source impedances. Applications include thermocouples, strain gages, accelerometers and other devices in the 100-500 $\mu$a range. The ST1051 offers low noise current of 0.05 millimicroampere rms and is designed for use with high source impedance. It is suited for 20-50 $\mu$a

# HOW SMALL

# CAN PRECISION COMPONENTS BE?

Synchros and associated components now can be small enough and light enough for use in many crucial assignments where size and weight must be minimal. Ketay has led the way in miniaturization without sacrifice of performance and environmental resistance.

Ketay's size 8 components meet and surpass current MIL design objectives. They are available in production quantities to meet strict delivery schedules.

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**Size 8 synchros**—only Ketay offers a complete line including high impedance units. Exclusive construction features—as well as stainless steel housing and materials of matched temperature coefficients—help assure high accuracy over a wide temperature range and resistance to corrosion and deformation.

**Size 8 servo amplifiers**—only Ketay offers transistorized 0.8 cubic inch units which deliver 2 watts output continuously from —55° to 100° C without a heat sink; 200 to 1000 volt normal gains can be supplied.

**Size 8 servo motors**—Ketay offers units of outstanding high ratio of stall torque to power input (0.25 oz. in. for 3.4 watt input at 6500 rpm), center-tapped for transistorized applications.

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RESOLVERS
POTENTIOMETERS
SERVO MOTORS
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SERVO AMPLIFIERS
GYROMECHANISMS
*Catalogues available.*

NORDEN DIVISION of United Aircraft Corporation

KETAY DEPARTMENT, Commack, Long Island, N.Y.



CIRCLE 76 READERS SERVICE CARD

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## Carrier Deviation Meter

**uses multi-crystal stability-lock**

**Direct indication of fm deviation**
From 200 cps to 125 kc makes this latest model in the Marconi 791 series applicable to both communication and broadcast fm systems.

**Crystal locking**
at any point in its 4- to 1024- mc carrier range brings new, exceptional stability and freedom from microphony in low-deviation measurements. Use of an external indicator extends the deviation range down to 10 cps, allowing fm hum and noise on uhf close-channel transmitters to be measured with ease and certainty.

**An in-built deviation standard,**
crystal governed, insures full rated accuracy at all times.

*Send for leaflet B143*

**ABRIDGED SPECIFICATIONS**
CARRIER DEVIATION METER 791D
*Carrier Frequency Range:* 4 to 1024 mc.
*Modulation Frequency Range:* 50 cps to 35 kc.
*Measures Deviation:* 200 cps to 125 kc in four ranges. Measures down to 10 cps using external readout.
*Measurement Accuracy:* ±3% of full-scale for modulation frequencies up to 25 kc.
*Internal FM:* Due to hum, noise and microphony, less than −55 db relative to 5 kc deviation.
*Tubes:* 6AK5, 6AS7, 6C4, 6CD6G, 5651, 5647, 5Z4G, OB2.

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*Marconi for f m test gear*

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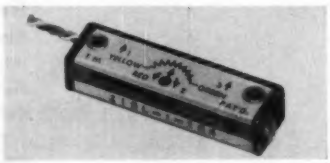
operation, typical current range for ionization gages, geiger tubes and photocells. **Circle 228 on Reader Service Card.**

## Transistor Tester self-contained

THE REFLECTONE CORP., Post Road and Myano Lane, Stamford, Conn. Model TT-1 provides tests for both *npn* and *pnp* type transistors, of the low, medium and high power types, and both socket and external leads are provided to accommodate the various transistor types. The tester checks leakage and gain characteristics as well as testing for shorts, and may also be used to check the reverse and forward current ratio on all diodes. The unit provides an easy-to-read sensitive 50 microampere movement. **Circle 229 on Reader Service Card.**



## Carbon Pot high temperature

BOURNS LABORATORIES, INC., P.O. Box 2112, Riverside, Calif. A new improved version of the model 215 Resiston carbon Trimpot is now available at an 18-percent reduction in selling price. It is a high temperature (125 C), high power (0.25 w at 70 C) carbon potentiometer designed to provide increased reliability at operating temperatures of 85 C and above;

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ARC selects

# FERRAMIC® CORE

## for Automatic Direction Finder

Space saving is illustrated by the fact that the core loop antenna protrudes only 2" outside aircraft skin compared to the 12" exterior structure of older air core loop antennas.

## Streamlined loop design saves weight, reduces air drag and increases sensitivity

Aircraft Radio Corp. selected General Ceramics Ferramic "E" Material for their new sub-miniature direction finder because it permitted a new concept of aircraft antenna design. Weight reduction of 80%, less air drag due to elimination of the cumbersome air core loop, and 50% lower cost were accomplished. Sensitivity was greatly increased. When your application involves magnetic material from 10 kcs. to 20,000 mcs. — ask the General Ceramics engineering advisory service for help in solving your problem. Address inquiries to General Ceramics Corporation, Keasbey, N. J.—Dept. E.

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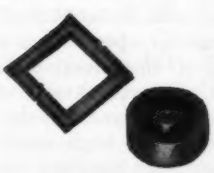
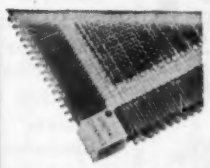
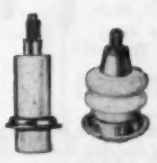

FERRAMIC CORES


MAGNETIC MEMORY CORES AND PLANES

PRECISION STEATITES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## from 50 KC to 600 MC

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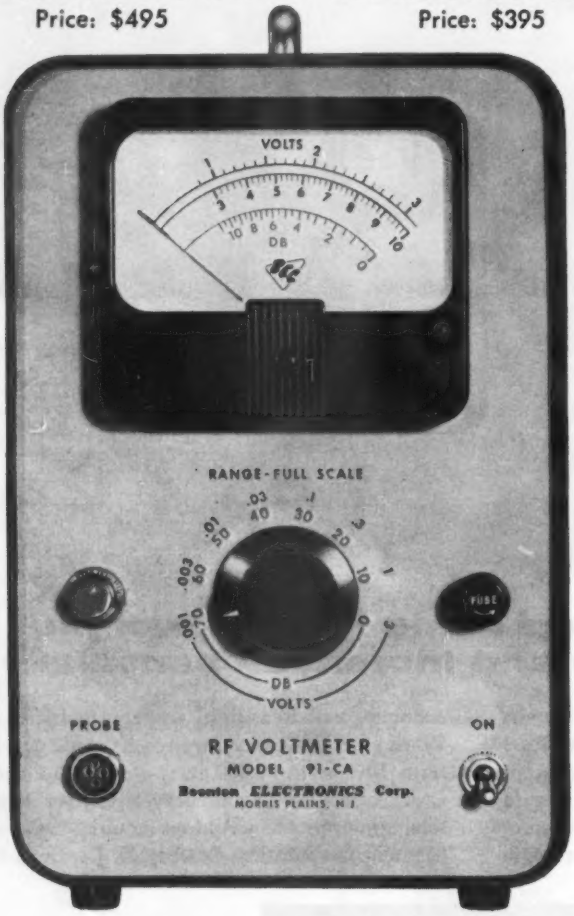
**300 microvolts to 3 volts**
Price: $495

MODEL 91-C
**1000 microvolts to 3 volts**
Price: $395




*ALSO MANUFACTURERS OF THE FOLLOWING INSTRUMENTS:*

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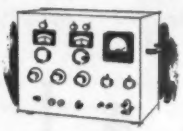
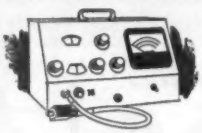

Capacitance Bridge


RF Distortion Meter

UHF Grid Dip Meter

**Boonton ELECTRONICS Corp.**

Morris Plains, N. J. • Phone: JEfferson 9-4210


and it meets all applicable requirements of MIL-STD-202. **Circle 230 on Reader Service Card.**

### Insulating Varnish fast air-drying

SCHENECTADY VARNISH CO., INC., Schenectady, N. Y. A clear, fast air-drying insulating varnish, which protects electrical and electronic equipment from fungus attack has been developed. Designated No. 642-AF fungicidal insulating varnish, it is applied to the surface of instruments, transformers, printed circuits, ceramic resistors, insulators and other electronic equipment subject to fungus attack in hot, humid climates. **Circle 231 on Reader Service Card.**

### Current Governor precision unit

NORTH HILLS ELECTRIC CO., INC., 402 Sagamore Ave., Mineola, N. Y. Model CS-11 current governor furnishes currents from 1 $\mu$a to 100 ma in steps of 1 $\mu$a at load voltages from 0 to 50 v. Current is set to five places by decade knobs arranged to provide a digital in line readout. Accuracy at any current setting is 0.02 percent +1 $\mu$a, short term stability 0.001 percent, line regulation is better than 0.0005 percent, and load regulation better than 0.002 percent. **Circle 232 on Reader Service Card.**

### Charge Amplifier all-transistorized

ENDEVCO CORP., 161 E. California St., Pasadena, Calif. Model 2620 all transistor amplifier operates on a new principle of amplification. It amplifies and converts charge to voltage. This advance design eliminates extremely high input impedances normally required for l-f response. The transducer and

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amplifier may now be placed up to 300 ft apart with no need for a cathode follower and without signal loss. Additional external capacitance between the transducer and amplifier causes no attenuation of the charge signal. **Circle 233 on Reader Service Card.**

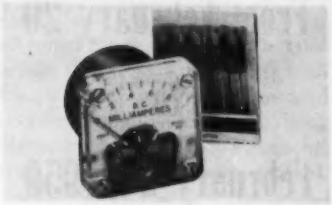
## Thermal Ribbon high temperature

MINCO PRODUCTS, INC., 740 Washington Ave. North, Minneapolis 1, Minn., has available a new model S6A thermal ribbon for temperature measurement and control applications to 260 C (500 F). Flexible, less than 0.020 in. thick, it measures ½ in. by 4 in. and is furnished with pressure-sensitive tape for installation to flat, curved, or irregular surfaces. Resistance is 676 ohms at 25 C, varying at a rate of 3.06 ohms per deg at 25 C. A calibration curve from −60 C to +260 C is furnished with each ribbon for quick conversion of resistance measurements to temperature. **Circle 234 on Reader Service Card.**

## Pulse Generator high current

CRANE ELECTRONICS CO., 4345 Hollister Ave., Santa Barbara, Calif. Model 24 pulser is a high current automatic cycling switch. It generates current pulses of up to 10 amperes. Unit is designed to operate from a nominal 28 v d-c and will deliver a 15 cps square wave of 28 v peak to peak suitable for driving stepping motors, relays, or solenoid actuators. High efficiency, absence of contact arc-

ing or bounce, and consistent performance over a long life are special features. **Circle 235 on Reader Service Card.**



## Panel Meters for limited space

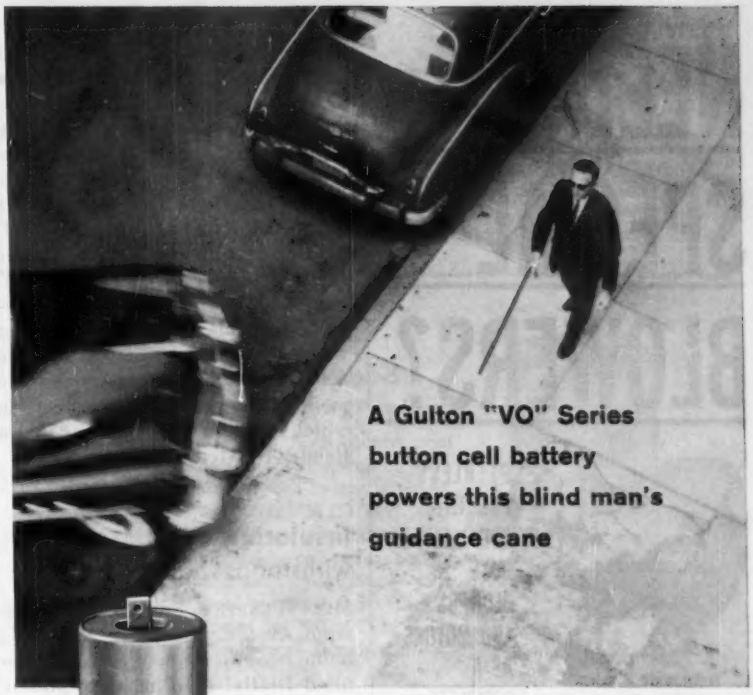
HOYT ELECTRICAL INSTRUMENT WORKS, INC., 42 Carleton St., Cambridge 42, Mass. A new series of panel meters are only 1½ in. sq, have a transparent plastic cover, are accurate to within 2 percent, and include a front zero adjustment. All meters in the new line are of the front opening type and feature standard mounting dimensions to facilitate interchangeability. Panel meters in d-c ranges are available from 100 $\mu$a, with an external shunt over 5 amperes; and self-contained rectifier types, VU, and voltmeters up to 300 v. **Circle 236 on Reader Service Card.**

## Pulse Amplifier miniaturized

CBS-HYTRON, Parker St., Newburyport, Mass. Type 6955 is a miniature, twin-triode featuring high pulse emission and fast operational warm-up. The 9-pin medium-mu amplifier is ideally suited for blocking oscillators, square-wave modulators and multivibrators; it can supply two amperes of peak current in 10-$\mu$sec pulses. The 6955 warms up rapidly to 80 percent of steady-state plate current within 10 sec. It has high resistance to the formation of cathode interface resistance. **Circle 237 on Reader Service Card.**

## Positioning Table automatic unit

TOPP INDUSTRIES, INC., 5221 W. 102nd St., Los Angeles 45, Calif. A new, larger size Micro-Posi-

**rugged . . . reliable . . . rechargeable!**

The cane in the man's hand is a proximity guidance device designed by Franklin Institute for the blind.

Requirements called for the power supply to be small enough to fit in the handle of the cane, rugged enough to perform well under abuse, and . . . to be rechargeable.

After extensive testing, designers chose the Gulton "VO" sealed nickel cadmium button cell battery to do the job.

**How Can You Use These Batteries?**

Powering this and other prosthetic devices is only one of many imaginative uses for these rechargeable batteries. Engineers have already designed them into transistorized radios, photo-flash power packs, missiles – wherever *small size, strength, light weight, long life, complete reliability, no maintenance and easy recharging are desired.*

**Most Complete Line Available**

"VO" cells are available in capacities of 100, 180, 250, 500 and 1750 mah; have a nominal 1.2 voltage; can be packaged in any combination to meet your voltage specs. Patented sintered plate construction provides exceptional cycling characteristics; highest capacity per unit size. Like more information? Write us for Bulletin No. VO-103.

ALKALINE BATTERY DIVISION
**Gulton Industries, Inc.**
Metuchen, New Jersey

CIRCLE 82 READERS SERVICE CARD

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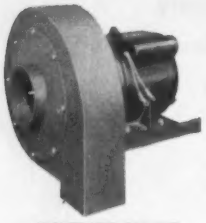
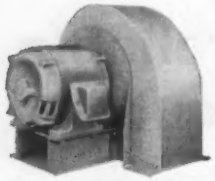


ELECTRONIC COOLING



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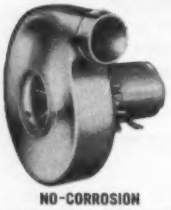
INSULATED FOR TEMPERATURES



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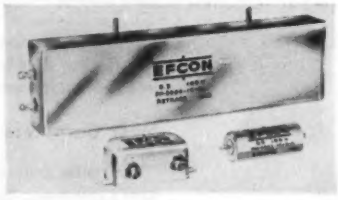
CIRCLE 83 READERS SERVICE CARD


tioner automatic positioning table has been introduced. The new table, which assures greater savings for industry, is a tape controlled, 2-axis, point-to-point positioning table with 16 in. by 24 in. working surface and 14 in. by 18 in. travel. It is a completely self-contained unit consisting of the table and control console which includes all programming and playback controls. Unit can be used with any existing vertical spindle machine tool and requires no modification of the machine with which it is used. **Circle 238 on Reader Service Card.**

## Insulating Plastic withstands 500 F

MESA PLASTICS CO., 11751 Mississippi Ave., Los Angeles 25, Calif., announces an economical asbestos-filled Diallyl Iso-Phthalate plastic that withstands prolonged exposure to temperatures up to 500 F. At 500 F, the material retains a flexural strength of 1,800 psi, a compressive strength of 6,000 psi, and a tensile of 4,300 psi, with substantially greater strengths at lower temperatures. The material has good electrical properties, high dimensional stability, and does not crack around metallic inserts. It resists acids, alkalis, solvents, fuels and corrosive chemicals. Postmold shrinkage is virtually zero, and weight loss very low at elevated temperatures. **Circle 239 on Reader Service Card.**




## Capacitors high stability

ELECTRONIC FABRICATORS, INC., 682 Broadway, New York 12, N. Y., announces high stability polystyrene dielectric capacitors with 0.03 to 0.01 percent retrace for use in laboratory standards, compensating networks, r-f filters and general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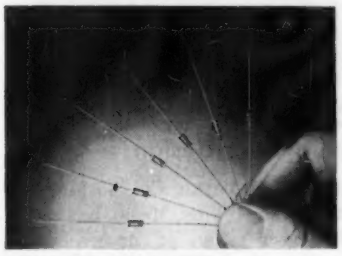
coupling applications. Characteristics include a temperature coefficient of −100 ppm/deg C, ±20 ppm. Insulation resistance is 1 million megohms per μf at 25 C, dielectric absorption 0.01 to 0.02 percent, and operating temperature range from 0 to +70 C. Dissipation factor at 1,000 cps is 0.05 percent. Various capacitance and voltage ratings are available, with tolerance ±5, ±2, ±1, ±½ percent. **Circle 240 on Reader Service Card.**

## Triode-Pentode nine-pin miniature

INTERNATIONAL ELECTRONICS CORP., 81 Spring St., New York 12, N. Y., announces the Mullard ECF80/6BL8, a nine-pin miniature triode-pentode, functioning as a high-gain a-f amplifier and phase inverter. Specially constructed heater windings which are center-tapped provide unusually low hum characteristics. The heater windings may also be grounded for additional balance and hum reduction. The basing and element construction are such that coupling between the two sections is non-existent, making the tube extremely desirable for integrated stereo amplifiers. **Circle 241 on Reader Service Card.**



## Germanium Diodes hermetically sealed

OHMITE MFG. CO., 3682 Howard St., Skokie, Ill., announces hermetically sealed germanium diodes in a subminiature glass package. They employ the superior gold-bonded construction in which a gold whisker wire is welded to the germanium pellet. Units are distinguished for their high forward conductance, high back resistance,


# 'DIAMOND H' RELAYS

## NEW . . . High Speed Polarized Relays

Fast action with freedom from bounce, plus high sensitivity and consistent operation with low distortion, are provided by small, rugged Series P Polarized Relays. SPDT, with two independent coils, they will handle over 1,000 pulses per second. Various coil resistances up to 5,000 ohms each coil. Contact ratings vary with switching speed but range from 60 MA to 2A with voltages to 120 AC or DC, dependent upon amperages employed.

## Aircraft-Missile Series R & S Relays

Miniature, hermetically sealed 4PDT, Series R & S relays provide excellent reliability over their long service life. Electrically and physically interchangeable, the two series differ only in that Series S coils are separately sealed within the sealed cases, with organic matter eliminated from the switch mechanism for greatest reliability in dry circuits. Contacts MA to 10 A.

## General Purpose AC, DC Relays

Series W Power Relays are DPDT, double break-double make; measure only 1½" x 1½" x 1⅜", but are rated to 25 A, resistive, at 112-230 V, AC, 1 HP 115 V, AC, 2 HP, 230 V, AC. Socket, panel and sidewall mountings are standard; others available to meet special needs. 12 possible contact arrangements, including sequencing.

**"Diamond H" engineers are prepared to work with you to develop variations on these relays to meet your specific requirements. Tell us your needs . . . by phone or letter.**

**THE HART MANUFACTURING COMPANY**

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| Length | 2 1/4" long | 2" long |
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| WRITE FOR: | Bulletin AWH TD-503 | Bulletin AWH TD-504 |

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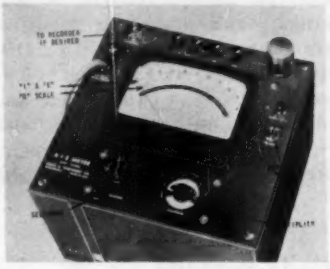
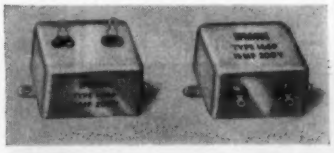
Design and Manufacture of Electro-Mechanical Timing Devices


and fast reverse recovery time. They are specially aged for stability. **Circle 242 on Reader Service Card.**



## R-I-E Meter stabilized unit

LEEDS & NORTHRUP Co., 4934 Stenton Ave., Philadelphia 44, Pa., announces a new R-I-E meter for lab and production testing. Applications include: resistance measurements from 2 megohms to 2 x $10^6$ megohms, with limits of error between ±1.7 and ±6 percent of reading; current measurements of 1 x $10^{-12}$ to 5 x $10^{-6}$ ampere, with limits of error between 1.5 and 3 percent of full scale; voltage measurements of 0.005 to 500 v, with limits of error between ±0.5 and ±3 percent of full scale. **Circle 243 on Reader Service Card.**



## Capacitors metallized design

SPRAGUE ELECTRIC Co., 35 Marshall St., North Adams, Mass., has available two types of drawn metal case "bathtub" metallized capacitors. Type 144P Difilm metallized capacitors use a dual dielectric consisting of both metallized paper and polyester film. Type 143P metallized paper capacitors are for those applications which do not require the high insulation resistance or other special performance characteristics of the type 144P. Complete data are given in bulletins 2220 and 2221 available on letterhead request.

## Power Supply
### voltage regulated

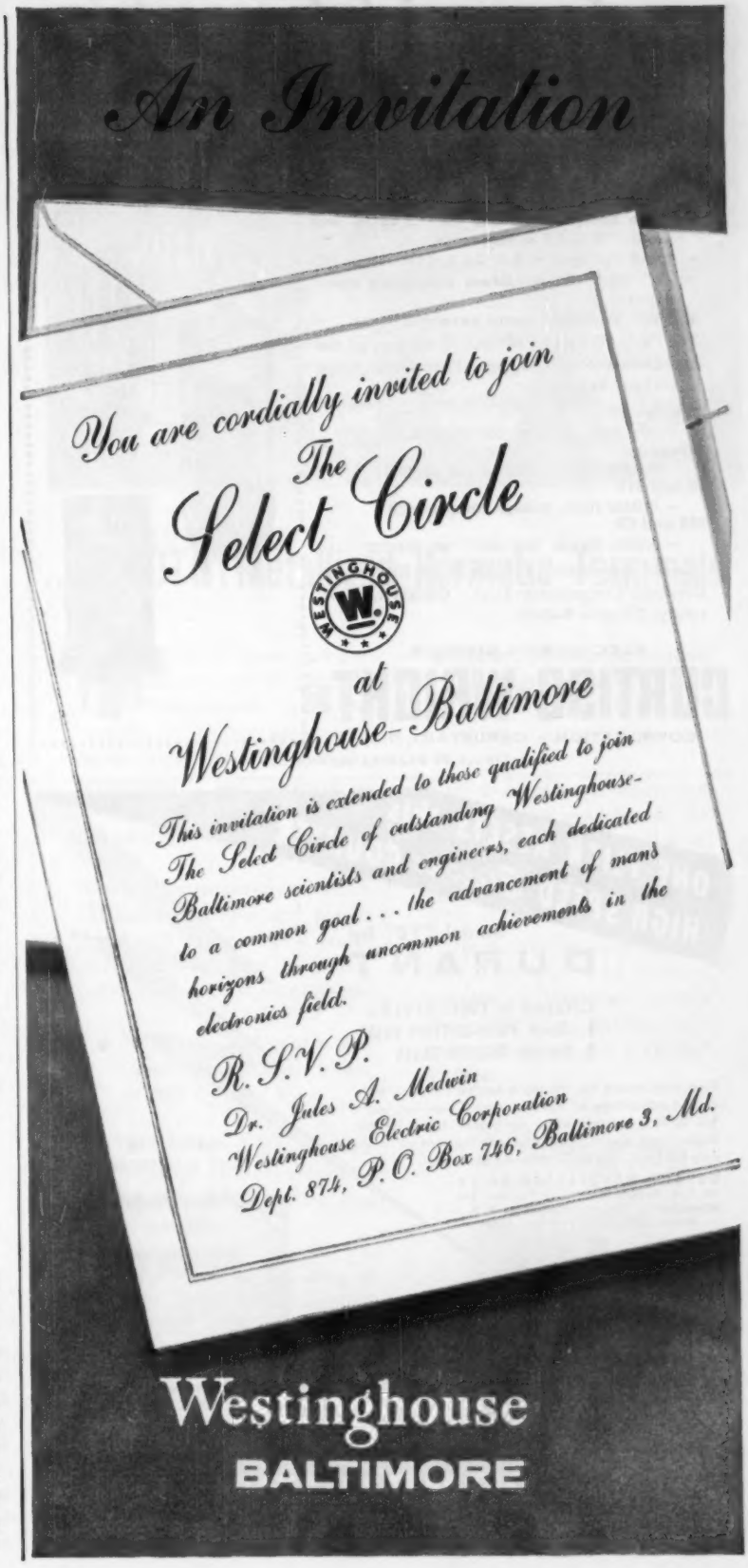
KEPCO LABORATORIES, INC., 131-38 Sanford Ave., Flushing 55, N. Y. The KM-254 compact tubeless magnetic voltage regulated power supply delivers in two ranges: 30 to 60 v, 0 to 4 amperes, and 60 to 90 v, 0 to 2.8 amperes. Regulation for line or load is less than ±1 percent. Ripple is less than 0.04 percent. **Circle 244 on Reader Service Card.**

## Signal Generator
### high-precision

BJ ELECTRONICS, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif. Excellent stability and constant high-level output of pulse-modulated r-f signals in the 10 cm band over a frequency range of 2,700 to 3,000 mc are features of the model 80 high-precision signal generator. Output of the instrument is internally monitored, continuously adjustable to as much as 10 w peak, and indicated by a meter mounted on the front panel. Controls are direct reading, eliminating the need for calibration charts. **Circle 245 on Reader Service Card.**

## Variable Capacitor
### voltage-sensitive

INTERNATIONAL RECTIFIER CORP., El Segundo, Calif. Semicap, a voltage-sensitive variable capacitor, opens up new design possibilities in oscillator control circuits. Its small size and weight, along with its high reliability and negligible power requirements, make it ideal for automatic frequency control, frequency modulation oscillators and bandpass, and filter networks where precision capacity control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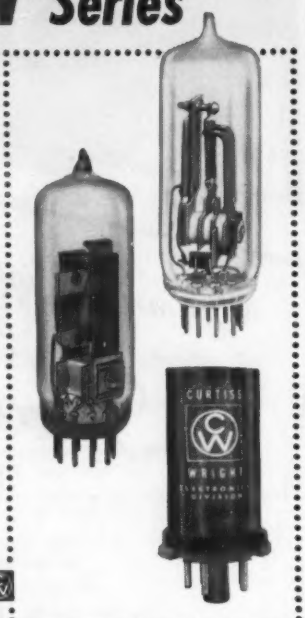


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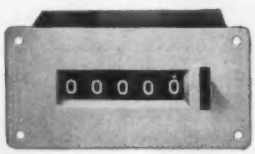


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is an essential design parameter. Semicap has a Q of 1,000 plus at 1 mc with a 10 to 1 capacity ratio well within its peak inverse voltage rating of 200 v d-c. **Circle 246 on Reader Service Card.**

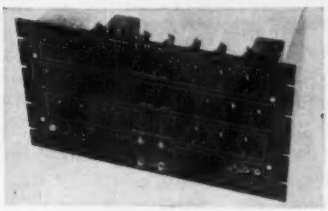
## Voltmeter Inverter
### wide reading range

MICRODYNE, 300 W. Washington St., Chicago 6, Ill. Type D-100 voltmeter inverter is a precision instrument for inversion of low level d-c to a-c, permitting the use of a conventional vtvm for low level d-c measurements at high impedance. Other uses include absolute measurement of voltage, as a null detector and, with external shunts, as an electronic galvanometer or millimicroammeter. Unit has a range of 100$\mu$v to 100 v. A-C meter scales are read directly in d-c. Price is $94. **Circle 247 on Reader Service Card.**

## Flight Simulator
### high response

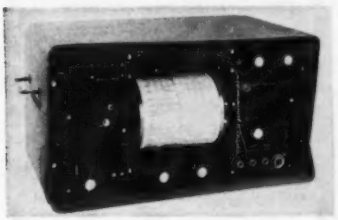
TASK CORP., 1009 E. Vermont Ave., Anaheim, Calif., announces a new low threshold, high response flight simulator. The 2-axis unit enables accurate testing of airborne electronic components over a full range of flight patterns. Advanced design makes possible the control of a wide range of rates and amplitudes from 0.004 deg to 240 deg and from 0.01 cps to 30 cps about either axis. The range permits testing of guidance components and systems through full fre-

quency range while extremely small friction allows controlled testing of gyro stability. Balanced design with two rotary actuators on each axis decreases total system error to less than 15 sec of arc. **Circle 248 on Reader Service Card.**



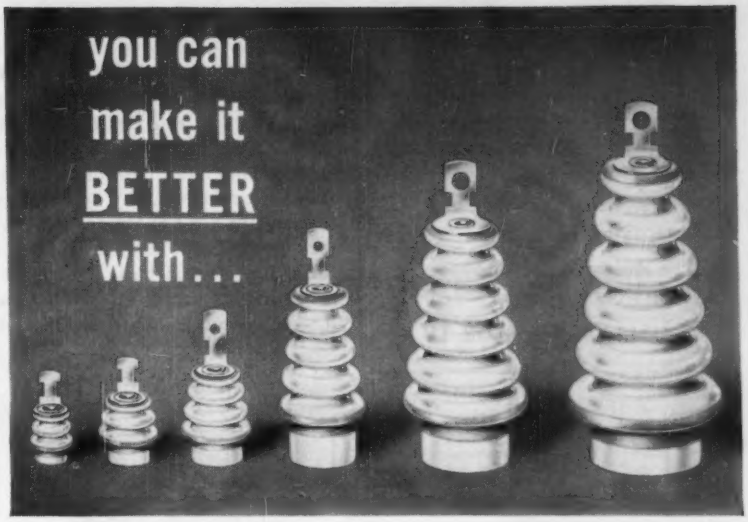
### Function Fitter for analog computing

GEORGE A. PHILBRICK RESEARCHES, INC., 285 Columbus Ave., Boston 16, Mass. Model FF Function Fitter is a versatile, self-contained rack-mounted analog computing component for the simulation of arbitrary functions of the input voltage. It features 10 straight line segments with adjustable tangent parabolic rounding, and adjustable slopes, break points, and offset. The unit is mounted on a 10½ in. rack panel, uses 100 ma at ±300 v, and about 80 w at 115 v a-c. Price is $875. **Circle 249 on Reader Service Card.**



### Plotter shows audio response

SOUTHWESTERN INDUSTRIAL ELECTRONICS Co., 2831 S. Post Oak Road, Houston, Texas. Quick, easy and permanent pen-written frequency response curves of any audio-range equipment are supplied economically by the ARP-2 audio response plotter. Input to the system to be tested is supplied by a 20-20,000 cps audio oscillator in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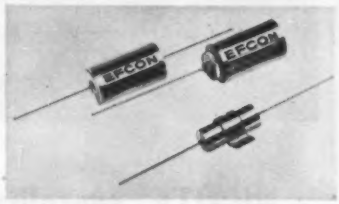


## Capacitors
### polystyrene

ELECTRONIC FABRICATORS, INC., 682 Broadway, New York 12, N. Y. A new line of reduced length polystyrene, hermetically sealed capacitors in which normal tubular capacitor lengths are reduced by at least 1/6 in. is announced. Units meet all existing military specifications in capacitance range from 0.001 $\mu$f to 100 $\mu$f, voltage ratings to 1,200 wvdc. Operating temperature range is from −65 C to 85 C without derating. Tolerances of ±5 percent and ±2 percent are available from standard production, and tolerances closer than ±1 percent may be specified. **Circle 251 on Reader Service Card.**

## Adapter Sleeves
### connector/cable

GLENAIR, INC., 1401 Air Way, Glendale 1, Calif., announces a new line of connector/cable adapter sleeves. Designated G1, the adapters are usable where there is insufficient room in an AN type backshell, or usable to adapt any AN connector to any size AN type clamp. Use of these adapter sleeves removes the possibility of strain at the solder pots and enables a good mechanical clamp to be made at the rear of the connector. **Circle 252 on Reader Service Card.**


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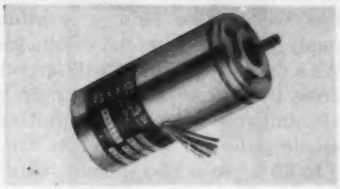
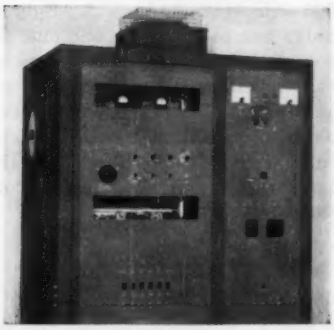


## Servomotor inertially damped

EASTERN AIR DEVICES, INC., 397 Central Ave., Dover, N. H., announces a high performance servomotor incorporating an inertial damper within Size 10, 11 or 15 frames. The compact unit is said to be electrically equivalent to the lead-lag network commonly used in servomechanism applications. Incorporation of the inertial damper within the servomotor frame results in substantial improvement in system performance for a given stability. It provides for maximum velocity constants; line frequency insensitivity; no wiring or pick-up problems; suppression of residual noise; noncritical adjustments and no loss in shaft output. Unit operates to 150 C. **Circle 253 on Reader Service Card.**



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LEVINTHAL ELECTRONIC PRODUCTS, INC., 760 Stanford Industrial Park, Palo Alto, Calif. Designed for klystron and twt tube development work, the model 70M hard-tube pulse modulator provides a flexible tool for experimental tube testing. It operates in two distinctly different modes: cathode pulsing, and modulating-anode pulsing. In either mode it operates anywhere


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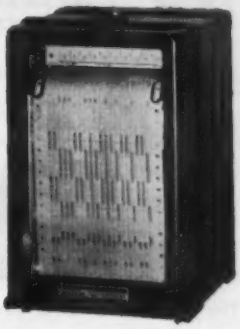

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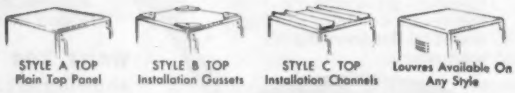
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in the range from 30 cps to 12,000 cps with pulse lengths continuously variable from 0.5 to 30 μsec. As a cathode pulser it will operate from 0 to 35 kv at currents up to 10 amperes. As a modulating-anode pulser it will operate from 0 to 35 kv to a 25-μμf load. **Circle 254 on Reader Service Card.**

## High-Mu Triode miniature size

NATIONAL UNION ELECTRIC CORP., Bloomington, Ill. The NU7235 is a high-mu triode in miniature size designed for amplifier and voltage regulator applications where up to 10,000 v are used. General characteristics are: mu 550; transconductance, 850 μmhos; plate dissipation, 10 w; overall height, 2¾ in.; maximum o-d, ⅞ in. Tube is of ruggedized construction. **Circle 255 on Reader Service Card.**

## Test Transformer with banana plugs

LENKURT ELECTRIC CO., San Carlos, Calif. Type 583A test transformer is designed for impedance matching between 600- and 75-ohm circuits, and facilitates measurements made in radio circuits with 600-ohm test equipment. Banana plugs are provided at one end for connection to test oscillators or vacuum-tube voltmeters. A coaxial connector at the other end permits patching to coaxial circuits with a test cord such as the Lenkurt type 693A. **Circle 256 on Reader Service Card.**

## Digital Clock automatic reset

DELTA-F, INC., Box 150, Geneva, Ill. Digi-Chron, the clock with digital time display, and providing primary frequency standard capabilities from 1 or 5 mc high sta-

# ROYAL COAXIAL CABLES*

Whatever your coaxial cable needs—for electronic equipment, for military applications, or for community TV installations—Royal's electronic cable production lines are ready to fill your requirements NOW.

For a quick look at the Royal Coaxial Cable line, request Bulletin No. 4C-3-L.



* Formerly manufactured by Federal Telephone & Radio Company

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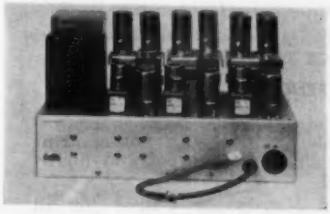
bility standards is announced. The instrument utilizes frequency counter techniques. It displays, in digital form, a cumulative total for a 24-hr period, automatically resetting to zero at this time and beginning a new count. Also featured is digital indication in millisec of the time difference between standard and transmitted time signals. **Circle 257 on Reader Service Card.**

## Noise Tube Mount direct reading

WAVELINE INC., Caldwell, N. J. Designed to extend the range of microwave r-f noise generating equipment, this new K band direct reading noise tube mount provides a means of quickly measuring noise figures in systems operating over the frequency range from 18.0 to 26.5 kmc. The assembly incorporates a precision calibrated attenuator which is directly marked in noise figure values. **Circle 258 on Reader Service Card.**

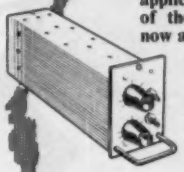


## Frequency Generator multirange

STERLING PRECISION CORP., 17 Matinecock Ave., Port Washington, N. Y. The T868 multirange frequency generator is a self-contained module. It incorporates tuning fork resonators and frequency dividing networks to supply accurate frequency reference voltages to T806 turntable rate motor drive amplifier, as well as other gyro test tables. **Circle 259 on Reader Service Card.**

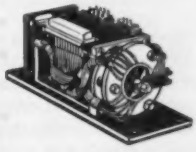

# A.W.A ELECTRONICS

**New concepts in electronics have been developed at AWA, as a result of experience with missile systems. Now they have a wider application. Here are some of the new AWA devices now available to industry.**



## TRANSISTOR GALVANOMETER AMPLIFIER

This Amplifier has been designed to drive viscous damped recording galvanometers which normally have a resistance of 50 ohms and a working range of D.C. to 2 Kc/s in frequency. The amplifier has a switched attenuator at its input and will accept single ended or push pull signals from ± 1 Millivolt to ± 500 volts and will feed a maximum of ± 50 Milliamps to the galvanometer. There is also a range of ancillary units available for use with this amplifier as part of a comprehensive instrumentation system. *Standard specification: Dimensions: 4½ in. x 3¾ in. x 10 in.; Frequency response: Flat from DC to 2 Kc/s, 5% down at 3 Kc/s, 3db down at 6 Kc/s; Noise level: 10 Microvolts at either input; Input impedance: 40,000 ohms on range 5, 110,000 ohms all other ranges; Gain: Maximum 3 Milliamps/Millivolt, minimum 0,04 Milliamps/Volt; Power requirements: ± 6 volts D.C. 220 Milliamps each line.*



## ROTARY SWITCH FOR TELEMETRY

Based on a conception of British Ministry of Supply's Research and Development Establishment, gives facilities previously unobtainable from mechanical sampling devices. The Standard Model enables two 24 channel banks to be sampled at speeds up to 200 r.p.s.

All devices are adaptable to suit customers' own requirements.
For further information consult:

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# Literature of

## MATERIALS

**Pressure-Sensitive Tapes.** Chart-Pak, Inc., Leeds, Mass. Over 545 pressure-sensitive tapes for making graphs, charts, printed circuit drawings and other presentations are illustrated in a 32-page booklet, "Visualization Made Easier". **Circle 275 on Reader Service Card.**

**Epoxy Compounds.** Biwax Corp., 3445 Howard St., Skokie, Ill. A new table of twenty epoxy compounds shows pot life, curing cycles, weight losses and gains, shrinkage, thermal shock and other special properties and applications. **Circle 276 on Reader Service Card.**

## COMPONENTS

**Transformers.** Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N. Y., devotes more than half of its new 24-page catalog to a description of the many types of transformers that can be produced as custom items. **Circle 277 on Reader Service Card.**

**Long-Life Capacitors.** Electro Motive Mfg. Co., Willimantic, Conn., has published a six-page, three-color folder fully describing the complete line of El Menco Dur-Mica capacitors. **Circle 278 on Reader Service Card.**

**Magnetic Amplifiers.** Vickers Inc., 1815 Locust St., St. Louis 3, Mo., has published a 36-page illustrated bulletin on the construction, operation and uses of magnetic amplifiers. Copies are available on company letterhead request.

**Pulse Transformers.** Technitrol Engineering Co., 1952 E. Allegheny Ave., Philadelphia 34, Pa. A new technical bulletin describes a series of miniature encapsulated pulse transformers wound on high permeability ferromagnetic cores. **Circle 279 on Reader Service Card.**

**Slip Rings.** Model Engineering and Manufacturing, Inc., 50 Frederick St., Huntington, Ind., has

# the Week

issued a new three-color flyer describing its activities in the slip ring, brush assembly and commutator fields. **Circle 280 on Reader Service Card.**

## EQUIPMENT

**Videotape Recorders.** Ampex Corp., 934 Charter St., Redwood City, Calif. An 8-page brochure discusses advanced applications of the VR-1000 Videotape recorder in cctv systems. **Circle 281 on Reader Service Card.**

**Miniaturized VTVM's.** Metronix, Inc., Chesterland, Ohio. Miniaturized electronic voltmeters in four basic styles are described in a new 4-page, short form catalog, No. 10-A. Data include performance specifications, dimensions and prices. **Circle 282 on Reader Service Card.**

**Oscillographs and Amplifiers.** Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio. An 8 page bulletin provides detailed engineering specifications, electrical characteristics, and construction of a wide variety of direct-writing oscillographs and associated amplifiers. **Circle 283 on Reader Service Card.**

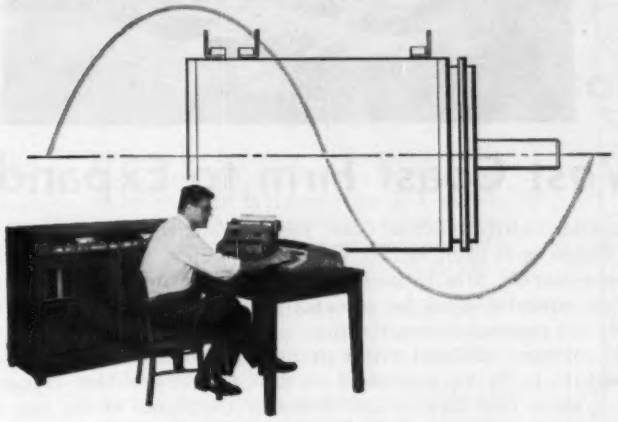
**Instruments.** Gyra Electronics Corp., 518 N. Spring Ave., La Grange Park, Ill. A recent 4-page folder contains descriptions, specifications and prices for an electrometer, linear amplifier, electrometer and vtvm, power supplies, exponential pulse generators, and reference voltage supply. **Circle 284 on Reader Service Card.**

## FACILITIES

**Cryogenics.** Arthur D. Little, Inc., 20 Acorn Park, Cambridge, Mass. *Kelvin Scale* is a news sheet of current information on cryogenics and related subjects, which will be published periodically by the company. **Circle 285 on Reader Service Card.**


SPECTROL PRECISION POTENTIOMETERS

How Spectrol uses an IBM 610 to design better **NON-LINEAR POTS**



Buying non-linear potentiometers is usually a big headache for the engineer interested in quick delivery and accurate performance.

First, you must provide the pot maker with detailed design requirements. Then wait until the design has gone through the manufacturer's engineering department... almost always a matter of weeks. Even then, the cut and try engineering approach ordinarily used often yields unsatisfactory results.

To solve this problem, Spectrol recently installed an IBM 610 Computer. Spectrol is the only precision potentiometer manufacturer to adapt IBM computer techniques within its own facilities to accurately compute non-linear functions. Using the computer, Spectrol makes complex non-linear precision potentiometers in record time, both single and multi-turn.

**How it works.** Design information in the form of X and Y coordinates or mathematical equations describing the particular parameters of a given non-linear function is entered in the computer. Previously programmed general equations automatically compute from these data points manufacturing directions in terms of winding equipment settings, cam angles and radii. Using a high speed electric typewriter as a readout, the directions are automatically printed on a form which is sent to production. Simultaneously, a punched tape is made to store information for repeat requirements.

**How the user benefits.** Because Spectrol's technique takes the guesswork out of non-linear potentiometer calculation, minimizes time consuming hand calculations, and provides error free results, the customer receives a superior product sooner. In quoting on particularly complex requirements, quote time is reduced from weeks to days. In emergencies, engineering and sales data can be prepared in a few hours.

Your nearby Spectrol representative will be happy to provide more information about Spectrol linear and non-linear precision potentiometers or you may write direct. A free Spectrol potentiometer specifications book is yours for the asking. Please address Dept. 181

SPECTROL ELECTRONICS CORPORATION

1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

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# West Coast Firm to Expand

FAIRCHILD SEMICONDUCTOR CORP. recently announced construction of a new 65,000 sq ft plant facility in Mountain View, Calif. This will enable the one-year-old firm to meet the demand for its initial products and provide expanded space for research projects in new semiconductor materials and parametric amplification.

The company, affiliated with Fairchild Camera and Instrument Corp. of Syosset, L. I., N. Y., announced its first products, silicon diffused transistors, about four months ago. Industry acceptance of the new devices, which provide a combination of very high speed switching performance, medium power and high temperature tolerance, was a prime factor in the decision to immediately expand production facilities, firm says.

According to the general manager, E. M. Baldwin, Fairchild Semiconductor is in quantity production of diffusion transistors. Principal application is in computer switching. Use in h-f amplifiers and oscillators is also anticipated.

Occupancy of the new million-dollar manufacturing plant is planned for May 1, at which time the present 20,000 sq ft facility at Palo Alto will be devoted to expanded research for greatly improved performance in long range surveillance radar, transmitters for space vehicles and very high speed electronic computers.

Until completion of the new plant, sizable production of present products is being handled at Palo Alto. By the end of 1959, Fairchild Semiconductor expects to have a total of 650 employees.

## Convair Ups R. E. Honer

NEW assistant chief engineer-electronics for the Convair (San Diego) Division of General Dynamics Corp. is R. E. Honer. He will be responsible for coordinating all Convair activities relative to enlarging and centralizing the division's internal electronics facility and organization.

Honer joined Convair in 1953 as a design specialist heading the microwave group. He was responsible for the design and development of microwave components, systems, antennas and radomes for projects in the electronics and guidance section.

Subsequently, he headed the division's radiation systems section and later, division electronics research.

## Rheem Appoints Handschumacher

THE NEWLY created position of corporate director of research and development at Rheem Mfg. Co., N.Y.C., was recently filled by A. G. Handschumacher. He continues also in his post as vice president and general manager of the company's Electronics Division.

Before joining Rheem in 1957, Handschumacher was senior vice president of Lear Inc. He is a director and member of the executive committee of Lear Inc. and a director of Solartron-Rheem, Ltd., a research and development company with headquarters in England.

## Daven Sets Up New Division

IN RESPONSE to a growing need for component reliability assurance processing equipment, The Daven Co., Livingston, N. J., has created a Reliability Assurance Division. The new division will provide the equipment required by the "mean-time-to-failure" contract provisions now in effect in a majority of weapons systems programs.

## Name Zillman General Manager

RECENTLY appointed general manager of Daystrom Pacific, Los Angeles, Calif., is Jack H. Zillman. He moves up from assistant general manager.

Zillman was formerly president

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## Aerocom's Dual Automatic Radio Beacon

Reliability is built into every part of this dual 1000-watt aerophare unit. Ruggedly constructed and conservatively rated, it provides trouble-free unattended service, and at truly low operating and maintenance cost. It operates in the frequency range 200-415 kcs, using plug-in crystal for desired frequency.

Uses single phase power supply, nominal 220 volts, 50 or 60 cycles. Consists of two 1 kw transmitters with 2 keyers, automatic transfer unit and weatherproof antenna tuner. Each transmitter housed in separate fan ventilated rack cabinet, with controls in center rack cabinet.

Nominal carrier power is 1000 watts. High level plate modulation of final amplifier is used, giving 35% modulation in Type A transmitter or up to 100% modulation in Type B transmitter. P-T switch interrupts tone, permitting voice operation. Operates in ambient temperatures from −35°C to 55°C, humidity up to 95%.

Standby transmitter is placed in operation when main transmitter suffers loss (or low level) of carrier power or modulation, or continuous (30 sec.) tone, or carrier frequency change of 5 kcs or more. Audible indication in monitoring receiver tells when standby transmitter is in operation.

Antenna may be either vertical tower or symmetrical T type.

Also available in
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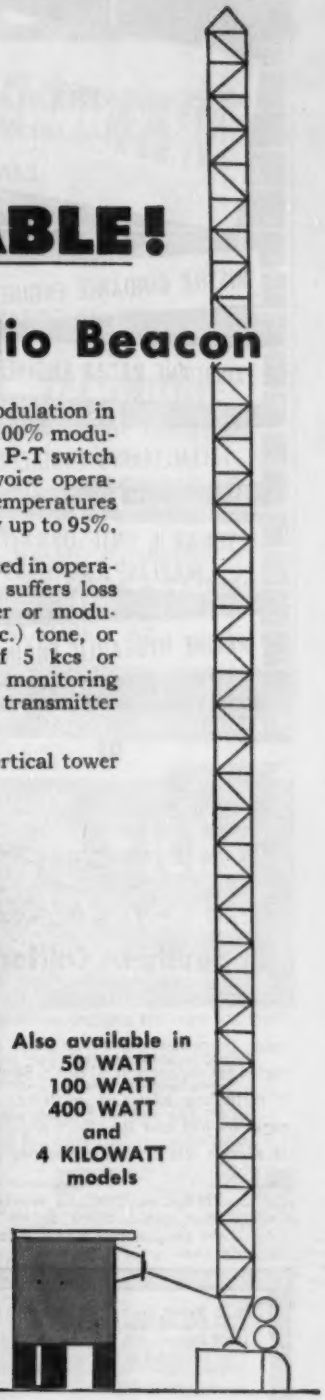

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There are important positions available in these small, independent engineering groups at Bendix-Pacific for engineers at all levels. Bendix-Pacific is particularly interested in strong, analytical engineers who have the calibre and capabilities to advance into systems engineering programs.

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of Whirlajet, Inc. and manager of U. S. Industries Research and Development Corp.

As general manager of Daystrom Pacific Division he will be responsible for expanding the company through research and development of new product and system concepts and through continuing the successful product improvement program started early last year.

## Appoint Schultz Senior Scientist

J. L. SCHULTZ recently joined Stavid Engineering, Inc., Plainfield, N. J., as senior scientist. For several years he has been responsible for the design and development of Airborne Early Warning Radar projects at the General Electric Co. in Utica, N. Y.

## Elsin Takes Up New Quarters

ACTIVE in the industry for the last 54 years, Elsin Electronics Corp. recently moved to a new building in Syosset, L. I., N. Y.

The plant is located on two acres and consists of 20,000 sq ft of space, divided into production, research and development, and administrative areas.

## Plant Briefs

New company engaged in the manufacture of glass-to-metal seals is **Palmer Associates,** Brockton,

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Mass. Technical director and president is Victor R. Palmeri.

Ground was broken recently at the Worcester, Pa., plant of **Daystrom Transicoil** for a new building to increase volume production of the company's line of servos, synchros, and related assemblies.

**Pearce Simpson, Inc.**, manufacturers of marine radiotelephones and associated equipment, recently moved into a new 20,000 sq ft factory and office building in Miami, Fla. Land area provides space for future expansion of an additional 20,000 sq ft.

## News of Reps

Fisher Berkeley Corp., Emeryville, Calif., announces appointment of the following reps for its Ektacom line of intercommunication equipment:

**James S. Heaton Company** of Redwood City, Calif., for northern California and northern Nevada; **John O. Olsen Company** of Cleveland, Ohio, for Ohio, western Pennsylvania and part of Kentucky; **W. C. Simonite & Company** of Los Angeles, Calif., for southern California, southern Nevada and Arizona.

**John Francis O'Halloran and Associates** is named sales rep in California, Nevada and Arizona for Weinschel Engineering, Kensington, Md.

King Electronics Co., Inc., Tuckahoe, N. Y., manufacturer of coax connectors, r-f components and cable assemblies, appoints the following reps:

**A. A. Dowers Co.**, of Huntington Park, Calif., for California, and Nevada; **Cirolia and LeBlank** of Walton, Mass., for Massachusetts, Vermont, New Hampshire, Maine and Rhode Island.

**Danco Corp.** of Fairview Village, Pa., is new sales-engineering rep in the eastern Pennsylvania, southern New Jersey, and Delaware areas for Power Sources, Inc., Burlington, Mass.


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"WORKED LIKE A CHARM!"

Richard Frank, Chief Engineer, Laboratory Instruments of Nuclear-Chicago Corporation says: *"Those special automatic voltage regulators worked like a charm. We could have achieved the same overall regulation in our electronic regulator by adding another stage but since the loop gain was already 20,000, the circuit stability would not have been comparable."*

Dick was referring to magnetic type regulated power transformers designed by Central engineers for his particular application. We can supply similar components custom made for your needs. Write or 'phone now for further information.

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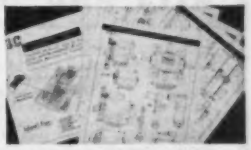

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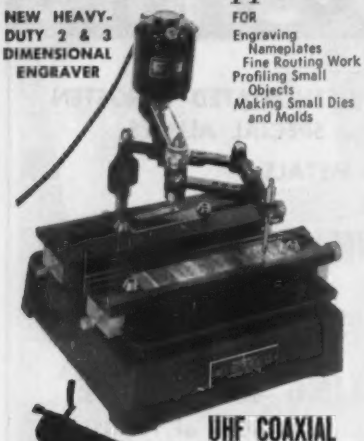

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# COMMENT

## Global Girdles

The recent successful launching of the 4½-ton tape-recorder satellite by the U.S. brought up a rather interesting discussion the other day.

It brought to mind a man-made toroid-ring satellite conceived by the remarkable Nikola Tesla when only 15 years old. He suggested constructing such a space-borne "tunnel" in light-alloy sections out in space, assembling it into a toroid and then setting it into stable spin with rockets. The purpose would be to provide global communications and transport. As with many other things, the visionary Tesla was half a century ahead of the sputniks—in concept at least.

A rather interesting reference was made recently in a science journal to a "global synchrotron" suggested by Enrico Fermi, using a globe-circling toroid and the earth's weak magnetic field. The idea was to use the tremendous throw of earth's radial velocity to accelerate particles to velocities near Mach 1, at which speed they generate Cerenkov radiation.

Several years ago, the writer suggested a global degaussing system, using a 10,000-amp aluminum cable looped clear around the earth, driven by an array of series-ganged turbo-driven homopolar generators. Long runs under the oceans could use sealed stations with atomic-reactor power plants. Such a global degaussing system could quite possibly have an appreciable effect not only on earth's magnetic field, but also on magnetic storms, ionospheric communications, and even the weather.

Judging from some comments that have been made in the scientific journals about the huge "time constant" of the earth's magnetic circuit, it would be most interesting to calculate the $dI/dt$ of such a magnetic loop.

TED POWELL

GLEN OAKS, L. I., N. Y.

**Well, the ring space station, fixed at 20,000-odd miles up and spinning on its own axis to provide**

NEW SEMICONDUCTOR DEVICE

**Halltron**

TYPE HS-51

HS-51

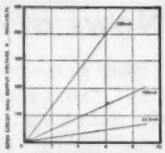
The HS-51 HALLTRON is based upon the Hall effect. Its output characteristics are related to the product of the input current and magnetic field, hence are useful in many new applications. The HS-51 HALLTRON is a fully developed production unit utilizing indium antimonide and is designed to work in the customer's magnetic circuit.

**Applications of the HS-51 HALLTRON**

- DC to AC converters
- Magnetic field measurement
- Computer applications
- Control applications
- Gyrators
- Circulators
- Power meters
- Transducers

**Typical Room Temperature Characteristics**

Typical open-circuit Hall output voltage of an HS-51 HALLTRON vs. magnetic field strength for various values of control current, $I_c$.



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**the illusion of gravity, is a definite project on which many good minds are now working. It has been a familiar idea for at least this decade past. Dr. Fermi's idea undoubtedly has merit of its own. But we wonder whether degaussing the earth wouldn't bring on a Pandora's box of trouble: such as bombardment by cosmic radiation, now substantially deflected by earth's magnetic field.**

### The Geophysical Year

Now that the International Geophysical Year (-and-a-half) has been formally closed, I'm wondering what it accomplished.

A lot of people poured a lot of sweat and money into this project. I would have thought that some results would've appeared by now.

Ironically, the one part of the project that cost the most and drew the most feverish popular attention — Vanguard — seems to have been the biggest frost. And the Atlas satellite, which was quite a piece of one-upmanship, wasn't even part of the IGY.

But where did all the money and time spent on IGY go?

RICHARD MACMULLEN
NEW ORLEANS

**We've got a communication from Hugh Odishaw, executive head of the U.S. National Committee for the IGY, which points out that it'll be months before all the data are even accumulated; reduction and analysis will occupy many scientists for years to come.**

### Traps in Tv

With reference to the article "Trap Improves Tv Picture" currently appearing in ELECTRONICS (p 100, Nov. 21'58):

Figs. 1 and 4 should be interchanged. In line 23 of the section "Basic Theory" (p 100, col. 3), $\theta_0$ should be $e_0$. Line 3 of "Bifilar T Trap" (p 100, col. 3) reads "because of the *balance* of varying. . . .", should read "because of the *absence* of varying . . ."

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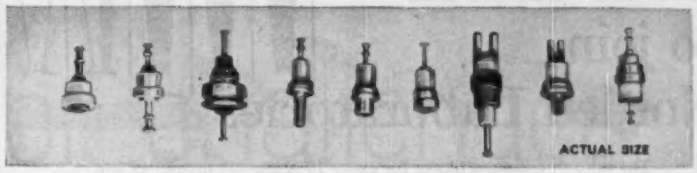


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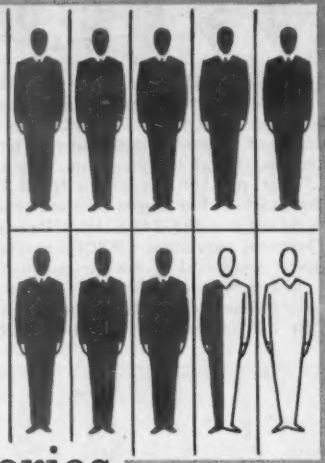

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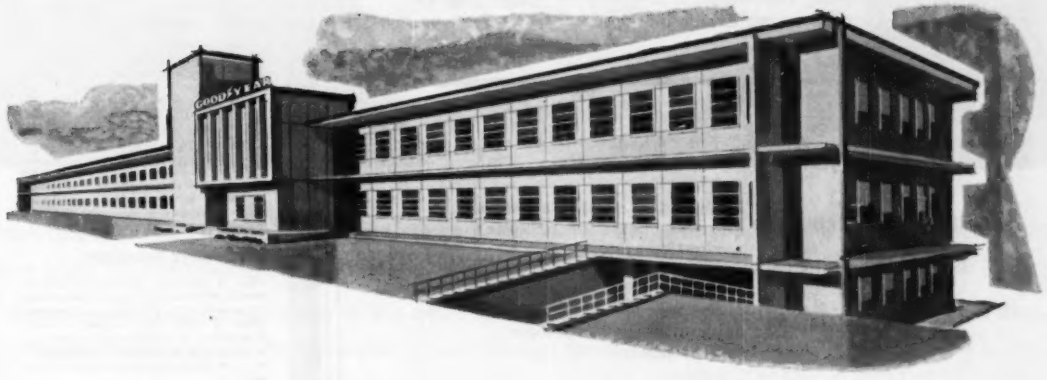


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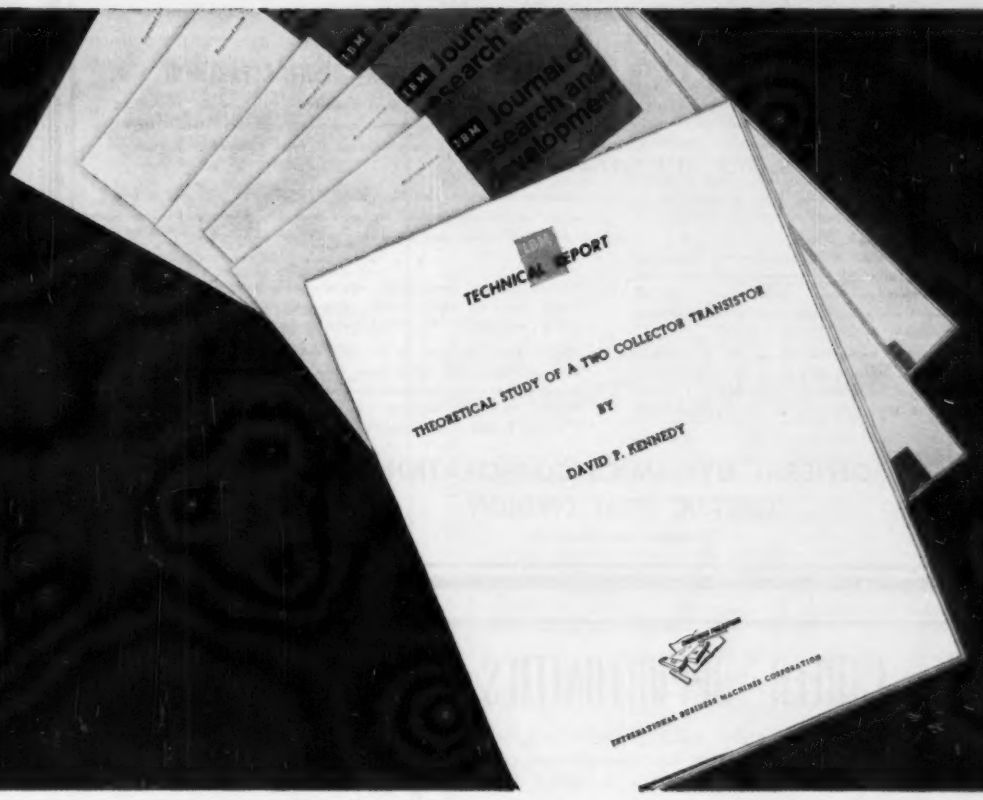


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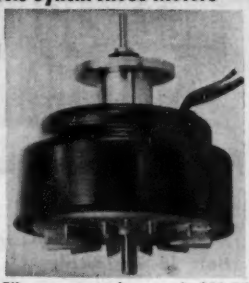

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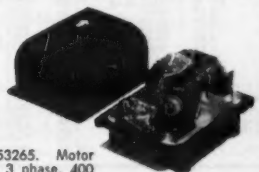
Input: 27.5 volts at 9.2 amps. AC. Output: 115 volts, 400 cycles; 3 phase, 100 voltamp; continuous duty. **Price $39.50 each**

MG54D Bendix Frequency & Voltage Reg.
Output: 200/115 volts; 400 cycle, single or 3 phase; .80 pf, 250 VA. Input: 28 VDC, 22 amps. **$99.50**

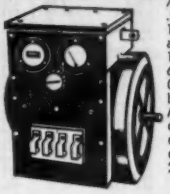
## SPERRY VERTICAL GYRO



Part #653265. Motor 115 volts, 3 phase, 400 cycle, 8 watts, 20,000 RPM. 3-minute runup, synchro pickoffs, roll 360°, pitch 85°. Synchro excitation 26 volts, 400 cycle, 150 m.a. Vertical accuracy ±½°. Weight 3½ lbs. Approx. dim. 5¾" L., 4½" W., 4½" H. **Price $35.00**

## 400 CYCLE, 3 PHASE GENERATOR

**BY MASTER ELECTRIC**

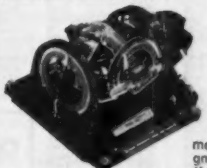


Type AG, frame 364Y, 7.5 kw, 3428 rpm, pf .95. Star connected 120/208 3 phase 22 amps. Delta connected 120 volt single phase 66 amps. Self excited. Complete with control box, voltage regulator, AC voltmeter and frequency meter. Shaft 1" dia., 2" long; overall dim. of unit: 21"x18"x 20".
Price **$395.00** each

## SYNCHROS SERVOS

| | |
|---|---|
| 1CT cont. Trans 90/55V 60 cy. | $34.50 |
| 1DG Diff. Gen. 90/90V 60 cy. | 34.50 |
| 1F Syn. Mtr. 115/90V 60 cy. | 34.50 |
| 1G Gen. 115V 60 cy. | 34.50 |
| 1HDG | 37.50 |
| 1HCT | 37.50 |
| 1HG | 37.50 |
| 1SF Syn. Mtr. 115/90V 400 cy. | 12.50 |
| 23TR6 torque receiver, 115/90 VAC, 60 cycle | 37.50 |
| 23CT6 control transformer, 90/1V per degree, 60 cycle | 37.50 |
| 23CX6 control transmitter, 115/90 VAC, 60 cycle | 37.50 |
| 5CT Cont. Trans. 90/55V 60 cy. | 34.50 |
| 5D Diff. Mtr. 90/90V 60 cy. | 34.50 |
| 5DG Diff. Gen. 90/90V 60 cy. | 34.50 |
| 5F Syn. Mtr. 115/90VAC 60 cy. | 34.50 |
| 5G Syn. Gen. 115/90VAC 60 cy. | 34.50 |
| 5HCT Cont. Trans. 90/55V 60 cy. | 37.50 |
| 5SDG Diff. Gen. 90/90V 400 cy. | 12.50 |
| 6DG Diff. Gen. 90/90V 60 cy. | 25.00 |
| 6G Syn. Gen. 115/90VAC 60 cy. | 34.50 |
| 7G Syn. Gen. 115/90VAC 60 cy. | 42.50 |
| 7DG differential generator, 90/90 volts, 60 cycle | 37.50 |
| C56701 Type 11-4 Rep. 115V 60 cy. | 20.00 |
| C69405-2 Type 1-1 Transm. 115V 60 cy. | 20.00 |
| C69406 Syn. Transm. 115V 60 cy. | 20.00 |
| C69406-1 Type 11-2 Rep. 115V 60 cy. | 20.00 |
| C76166 Volt. Rec. 115V 60 cy. | 10.00 |
| C78248 Syn. Transm. 115V 60 cy. | 12.50 |
| C78249 Syn. Diff. 115V 60 cy. | 5.00 |
| C78410 Repeater 115V 60 cy. | 20.00 |
| C78863 Repeater 115V 60 cy. | 7.50 |
| C79331 Transm. Type 1-4 115V 60 cy. | 20.00 |
| 851 Bendix Autosyn Mtr. 22V 60 cy. | 7.50 |
| 403 Kollsman Autosyn Mtr. 32V 60 cy. | 7.50 |
| FPE-25-11 Diehl Servo 75/115 v 60 cy. | 12.50 |
| FPE 49-7 Diehl servo motor, 115 volts, 60 cycle, 10 watts | 30.00 |
| FPE-43-1 Resolver 400 cy. | 19.50 |
| FJE-43-9 Resolver 115V 400 cy. | 15.00 |
| R110-2A Kearfott Cont. Mfr. | 17.50 |
| R200-1-A Kearfott Cont. Trans. | 15.00 |
| R220-1 Kearfott Receiver | 20.00 |
| R235-1A Kearfott Resolver | 20.00 |

## HONEYWELL VERTICAL GYRO MODEL JG7003A-1



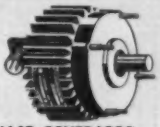
115 volts, 400 cycles, single phase, 35 watts. Pitch and roll Potentiometer pickoffs 890 ohms, 40 volts max. AC or DC. Speed 20,000 rpm, ang. momentum 12,500,000 gm-cm ²/sec. Erection system 27 VAC, 400 cycles, time 5 min. to ½°. Weight 5.5 lbs.
Price **$35.00** each

## HIGH-QUALITY OPTICAL PARTS

**5" Schmidt Ultra Hi-Speed Objective Lens System**

Eastman Kodak infra-red receiver, formerly known as U.S. Navy Metascope, Type B, 7" long with 5" SCHMIDT ultra-high speed Objective Lens (approx. f 0.5). Elaborate optical system, many coated lenses. Uses 2 penlight batteries. Govt. cost approx. $300. Factory-new. Shipping wt. 9 lbs. Price **$19.95**
Waterproof Carrying Case, extra. Shipping wt. 3 lbs. Price **$3.00**
Dual purpose U.S.N. floodlight throws strong beam of invisible infra-red rays. With infra-red lens, spare sealed beam lamp, batteries. Shipping wt. 23 lbs. **$14.95**

## 400 CYCLE PM GENERATOR



115/200 volts A.C. 1- or 3-phase, 200 watts. 4,000 r.p.m. Approx. dimensions: 4¾" dia.; 3" long; ½" shaft, AN connector. **$75.00**

**400 CYCLE ⅓ PHASE GENERATOR**

115 VAC. 3 KVA. Mfg. Bogue Elect. Mod. 28005. External excitation 107 VDC. 1.1 amp. 3450 rpm. 1" shaft. **$200.00**

## GENERAL ELECTRIC AUTO PILOT DIRECTIONAL GYRO INDICATOR and CONTROL UNIT

Mod. 8K63AC. 115 volts, 400 cps, 3 phase, 40 watts. Has settable induction pick-off. **$10.00**

## VARIABLE SPEED BALL DISC INTEGRATORS

**No. 145**

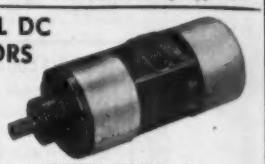
Forward & Reverse 2¼-0-2¼. Input shaft spline gear 12 teeth 9/32" dia. 3/8" long. Output shaft 15/64" dia. x 15/32" long. Control shaft 11/32" x 3/8" long. Cast aluminum construction. Approx. size 3" x 3" x 2¾".

**No. 146**

Forward & Reverse 4-0-4. Input shaft 5/16" dia. x ¾" long. Output shaft 15/64" dia. x 9/16" long. Control shaft 11/64" dia. x 11/16" long. Cast aluminum construction. Approx. size 4½" x 4½" x 4". **(All Shafts Ball Bearing Supported)**

**$17.50 ea.**

## SMALL DC MOTORS



(approx. size overall 3¾" x 1¼" dia.)

| | |
|---|---|
| 5067043 Delco 12 VDC PM 1" x 1" x 2", 10,000 rpm. | $7.50 |
| 5067126 Delco PM, 27 VDC, 125 RPM, Governor Controlled | 15.00 ea. |
| 5069600 Delco PM 27.5 VDC 250 rpm | 12.50 |
| 5069230 Delco PM 27.5 VDC 145 rpm | 15.00 |
| 5068750 Delco 27.5 VDC 160 rpm w. brake | 6.50 |
| 5068571 Delco PM 27.5 VDC 10,000 rpm (1x1x2") | 5.00 |
| 5069790 Delco PM, 27 VDC, 100 RPM, Governor Controlled | 15.00 ea. |
| 5072735 Delco 27 VDC 200 rpm governor controlled. | 15.00 |
| 5BA10A118 GE 24 VDC 110 rpm | 10.00 |
| 5BA10AJ37 GE 27 VDC 250 rpm reversible | 10.00 |
| 5BA10AJ52 27 VDC 145 rpm reversible | 12.50 |
| 5BA10AJ50, G.E., 12 VDC, 140 rpm | 15.00 |
| 5BA10FJ401B, G.E. 28 VDC, 215 rpm, 10 oz. in., .7 amp, contains brake | 15.00 |
| 5BA10FJ421, G.E. 26 VDC, 4 rpm, reversible, 6 oz. in., .65 amp | 15.00 |
| S. S. FD6-31 Diehl 24 VDC PM 10,000 rpm. 1" x 1" x 2". | 4.00 |

# Jsh ELECTRONICS CO.

Dept. E-1

1108 Venice Boulevard • P.O. Box 15654
Los Angeles 15, California • Richmond 9-7644

Cable Address: JASHELEC  Telegraph: FAX

# TUBES

★ NEW ★ NAME BRANDS
★ IMMEDIATE DELIVERY
★ LOW PRICES
★ UNCONDITIONAL GUARANTEE

## NEW LOW PRICES

| | | |
|---|---|---|
| C1K ..... 650.00 | 2K50 ..... 115.00 | SSP7A ..... 40.00 |
| OA2 ..... .60 | 2K54 ..... 13.00 | SXP2 ..... 65.00 |
| OA2WA ..... 2.00 | 2K55 ..... 13.00 | SXP2A ..... 65.00 |
| OB2 ..... .50 | 2K56 ..... 90.00 | SXP7 ..... .50 |
| OB2WA ..... 1.75 | 2N43 ..... 5.75 | SXP11 ..... .50 |
| OB3/VR90 ..... .70 | 2N132 ..... Q | SXP11A ..... 50.00 |
| OC3/VR105 ..... .70 | 2N3986 ..... 7.00 | SX15B ..... 65.00 |
| OC3W ..... 2.00 | 2X2 ..... .25 | SX2P5 ..... 65.00 |
| OD3/VR150 ..... .40 | 2X2A ..... 1.00 | SY3WGT ..... 1.50 |
| OD3W ..... 2.00 | 3AP1 ..... 1.50 | EL-C6J ..... 10.00 |
| 1AE4 ..... 1.00 | 3ARP1 ..... 25.00 | 6AC7A ..... .75 |
| 1B22 ..... 2.00 | 3ARP2 ..... 25.00 | 6AC7W ..... 1.00 |
| 1B24 ..... 2.00 | 3ASCP7 ..... 15.00 | 6AD4 ..... 1.50 |
| 1B24A ..... 5.00 | 3B4 ..... 1.50 | 6AJ5 ..... 1.50 |
| 1B25 ..... 1.25 | 3BP1 ..... 1.25 | 6AK5 ..... .90 |
| 1B26 ..... .60 | 3BP3 ..... 3.25 | 6AL5W ..... 1.25 |
| 1B27 ..... 6.50 | 3B24 ..... .50 | 6AL5W ..... .60 |
| 1B29 ..... 2.50 | 3B24W ..... 3.50 | 6AN5 ..... 1.50 |
| 1B35 ..... 2.50 | 3BP24WA ..... 7.00 | 6AN5W ..... 4.25 |
| 1B35A ..... 3.75 | 3B25 ..... 4.25 | 6AN6 ..... 2.00 |
| 1B37 ..... 2.00 | 3B26 ..... 2.00 | 6AR6 ..... 1.25 |
| 1B38 ..... 12.00 | 3B28 ..... 4.00 | |
| 1B40 ..... 1.00 | 3CP1 ..... 1.95 | |
| 1B41 ..... 40.00 | 3C22 ..... 17.00 | |
| 1B42 ..... 5.00 | 3C23 ..... 5.00 | |
| 1B44 ..... 8.00 | 3C24/24G ..... 2.75 | |
| 1B45 ..... 9.50 | 3C27 ..... .75 | |
| 1B47 ..... 2.00 | 3C30 ..... 2.50 | |
| 1B51 ..... 6.75 | 3C33 ..... 4.50 | |
| 1B53 ..... 6.00 | 3C45 ..... 4.50 | |
| 1B53/R1130B 10.00 | 3DP1A ..... 5.00 | |
| 1B62 ..... 1.75 | 3D21A ..... 2.50 | |
| 1B63A ..... 12.50 | 3E29 ..... 7.00 | |
| 1N21B ..... 2.00 | 3FP7A ..... 2.00 | |
| 1N23B ..... .60 | 3JP1 ..... 6.50 | |
| 1N23B M ..... 2.00 | 3JP7 ..... 2.00 | |
| 1N23C ..... 2.10 | 3J30 ..... 20.00 | |
| 1N25 ..... 1.00 | 3J31 ..... 42.50 | |
| 1N26 ..... 1.00 | 3KP22 ..... 150.00 | |
| 1N27 ..... .70 | 3KS0 ..... 90.00 | |
| 1N28 ..... 6.00 | 3WP1 ..... 10.00 | |
| 1N29 ..... 1.00 | 3WP2 ..... 12.00 | |
| 1N32 ..... 8.00 | 3WS80A3 ..... 95.00 | |
| 1N34A ..... .45 | 4-65A ..... 12.50 | |
| 1N40 ..... 1.50 | 4-250A ..... 22.00 | |
| 1N41 ..... 6.50 | 4-400A ..... 40.00 | |
| 1N42 ..... 8.00 | 4-1000A ..... 90.00 | |
| 1N44G/400D ..... .25 | 4A1 ..... 1.25 | |
| 1N47 ..... 1.50 | 4B23 ..... 4.00 | |
| 1N52 ..... .40 | 4B24 ..... 6.50 | |
| 1N53 ..... 1.75 | 4B24/EL3C ..... 6.00 | |
| 1N56 ..... .60 | 4C22/HP300 12.00 | |
| 1N58 ..... .90 | 4C27/CV52 ..... 7.00 | |
| 1N63 ..... .75 | 4C28 ..... 15.00 | |
| 1N69 ..... .35 | 4C32 ..... 15.00 | |
| 1N85 ..... .70 | 4C35 ..... 12.50 | |
| 1N151 ..... 1.25 | 4D21 ..... 22.00 | |
| 1N230 ..... 1.80 | 4E27 ..... 8.00 | |
| 1N252 ..... 1.50 | 4E27A ..... 30.00 | |
| 1N338 ..... Q | 4J21-4J64 ..... Q | |
| 1N342 ..... Q | 4PR60A ..... 20.50 | |
| 1P21 ..... 27.50 | 4W20 20,000A 750.00 | |
| 1P22 ..... 4.00 | 4X150A ..... 15.00 | |
| 1P24 ..... 1.25 | 4X150G ..... 15.00 | |
| 1P25 ..... 15.00 | 4X150GB ..... 15.00 | |
| 1P28 ..... 12.00 | 4X500A ..... 65.00 | |
| 1P30 ..... 2.50 | 5AS ..... 1.25 | |
| 1P31 ..... 2.50 | 5B1P/5C30 ..... 1.75 | |
| 1P35 ..... 1.20 | 5BP1A/6278 ..... 25.00 | |
| 1Q22 ..... 12.50 | 5AP1 ..... 2.00 | |
| 1W3 ..... Q | 5BDP7 ..... 100.00 | |
| 1Z2 ..... 1.40 | 5BP2A ..... 5.00 | |
| 2AC15 ..... 7.00 | 5BP4 ..... 2.00 | |
| 2AP1 ..... 2.00 | 5BP7A ..... 1.50 | |
| 2AP1A ..... 3.50 | 5CP1A ..... 6.50 | |
| 2AS15A ..... 6.25 | 5CP7 ..... 3.00 | |
| 2B22 ..... 1.00 | 5CP7A ..... 3.00 | |
| 2B24 ..... 1.00 | 5CP11A ..... 7.50 | |
| 2C26A ..... .25 | 5C22 ..... 18.00 | |
| 2C33/RK233 ..... .60 | 5C24 ..... 30.00 | |
| 2C34/RK34 ..... .25 | 5DC5 ..... 8.75 | |
| 2C35 ..... 2.00 | 5DC5M ..... 9.50 | |
| 2C36/6468 ..... 20.00 | 5DP1 ..... 4.75 | |
| 2C37 ..... 15.00 | 5R4WGY ..... 2.75 | |
| 2C39A ..... 9.00 | 5RP11A ..... 65.00 | |
| 2C40 ..... 6.00 | | |
| 2C42 ..... 5.00 | | |
| 2C43 ..... 7.00 | | |
| 2C46 ..... 4.00 | | |
| 2C50 ..... 5.00 | | |
| 2C51 ..... 2.00 | | |
| 2C52 ..... 2.00 | | |
| 2C53 ..... 8.75 | | |
| 2D21 ..... .90 | | |
| 2D21W ..... 1.00 | | |
| 2D25 ..... .60 | | |
| 2E22 ..... 2.50 | | |
| 2E24 ..... 2.50 | | |
| 2E25A ..... 2.00 | | |
| 2E26 ..... 1.50 | | |
| 2E27 ..... .60 | | |
| 2E32 ..... 1.00 | | |
| 2H21 ..... Q | | |
| 2J21-2J30 ..... Q | | |
| 2J31-2J39 ..... Q | | |
| 2J42 ..... 88.00 | | |
| 2J43 ..... 88.00 | | |
| 2J42H ..... 60.00 | | |
| 2J51 to 2J62A ..... Q | | |
| 2K22 ..... 28.00 | | |
| 2K25 ..... 12.00 | | |
| 2K26 ..... 34.50 | | |
| 2K28 ..... 30.00 | | |
| 2K33 ..... 100.00 | | |
| 2K33A ..... 60.00 | | |
| 2K34 ..... 100.00 | | |
| 2K41 ..... 100.00 | | |
| 2K42 ..... 100.00 | | |
| 2K44 ..... 100.00 | | |
| 2K45 ..... 35.00 | | |
| 2K46 ..... 195.50 | | |
| 2K47 ..... 100.00 | | |
| 2K48 ..... 35.00 | | |

| | | |
|---|---|---|
| VCR-32 ..... 6.00 | 35A ..... 7.50 | 832 ..... 2.75 |
| V-50 ..... 125.00 | 356B ..... 2.50 | 832A ..... 7.00 |
| V-50XR125.00 | WE-359A ..... .00 | 834 ..... 3.50 |
| HK-54 ..... 2.00 | 371B ..... 1.50 | 836 ..... 1.50 |
| FG-57 ..... 8.00 | 371A ..... 1.50 | 837 ..... 1.10 |
| QK-57 ..... Q | 374A ..... 1.50 | 838W ..... 6.00 |
| QK-59 ..... 15.00 | 375A ..... 7.00 | 843 ..... .25 |
| QK-60 ..... 15.00 | QK381 ..... 65.00 | 849 ..... 24.50 |
| RK-60/1641 ..... 1.10 | 388A ..... Q | 851 ..... 5.00 |
| QK-61 ..... 15.00 | WE-388A ..... .60 | 852 ..... 4.00 |
| QK-62 ..... 15.00 | 393A ..... 6.00 | 860 ..... 1.00 |
| HY65 ..... .80 | WE-396A ..... 2.75 | 861 ..... 35.00 |
| FG-67 ..... 6.00 | 398A ..... 8.00 | 865 ..... .25 |
| HY-69 ..... 2.00 | 403B/5591 ..... 2.50 | 866JR ..... 1.20 |
| 72 ..... .50 | QK404 ..... 30.00 | 872A ..... 1.00 |
| 73 ..... .50 | WE404A ..... 2.00 | 874 ..... .70 |
| FG-81A ..... 5.00 | WE-407A ..... 1.00 | 876 ..... .50 |
| FG-95 ..... 12.50 | WE-408A ..... 1.75 | 878 ..... 1.00 |
| BL96 ..... Q | WE-409A ..... 1.65 | 884 ..... .75 |
| FG97 ..... 25.00 | WE-412A ..... 2.00 | 889NA ..... 75.00 |
| FG98A ..... 28.00 | GL-414 ..... Q | 891 ..... 100.00 |
| BL-98 ..... Q | WE-415A ..... 3.00 | 891R ..... 125.00 |
| ML-100 ..... 45.00 | WE-416B ..... 35.00 | 902P1 ..... 2.00 |
| HF-100 ..... 12.50 | WE-417A ..... 2.25 | 905 ..... 5.00 |
| 100P ..... 1.50 | WE-417A ..... 2.00 | 917 ..... 1.00 |
| 100TH ..... 6.50 | WE-419A ..... 10.00 | 918 ..... .90 |
| WE-101D ..... 2.00 | WE-420A ..... 5.50 | 919 ..... 1.25 |
| WE101F ..... 2.00 | WE-421A ..... 6.00 | |

| | | |
|---|---|---|
| 6AS6 ..... .75 | WE-121A ..... 1.25 | WE-422A ..... 7.00 |
| 6AS6W ..... 1.50 | F-123A ..... 4.75 | WE-423A/ |
| 6AS7G ..... 2.00 | VT-127A ..... 2.50 | 6140 ..... 5.00 |
| 6AU6WA/6136 1.90 | F-128A ..... 7.00 | WE-431A ..... Q |
| 6BF7 ..... 1.25 | FG-154 ..... 7.00 | 432A ..... 6.50 |
| 6BF7W ..... 1.50 | VT-158 ..... 9.50 | 432B ..... 8.00 |
| 6BL6 ..... 30.00 | FG-166 ..... 6.50 | 434A ..... 4.50 |
| 6BM6 ..... 27.50 | QK172 ..... 400.00 | QK436 ..... 200.00 |
| 6BM6A ..... 32.50 | GK-181 ..... 10.00 | QK437 ..... 500.00 |
| 6C21 ..... 13.50 | WL-200 ..... 50.00 | 446A ..... .65 |
| 6D4 ..... 1.00 | QK202 ..... 100.00 | 446B ..... 1.00 |
| 6D21 ..... 175.00 | 203A ..... 2.00 | 450TH ..... 40.00 |
| 6HGWGT ..... 3.25 | VA-203B ..... 150.00 | 450TL ..... 40.00 |
| 6J4 ..... 1.00 | 204B ..... 10.00 | WL-456 ..... 85.00 |
| 6J41WA ..... 1.25 | 205F ..... 3.00 | QK459 ..... 250.00 |
| 6J5WGT ..... 1.00 | 207 ..... 50.00 | 460 ..... 8.00 |
| 6J5GWGT ..... 1.00 | VT4C ..... 1.75 | 464A ..... 2.75 |
| 6J6WA ..... 1.50 | 211E ..... 10.00 | 5A466/1D21 ..... 4.50 |
| 6K4 ..... 2.00 | 212E ..... 13.00 | GL-471A ..... 2.00 |
| 6L6WGA/5932 2.00 | 214B ..... 2.75 | QK472 ..... 200.00 |
| 6L6WGB ..... 1.50 | 217C ..... 1.25 | X481D ..... 95.00 |
| 6SK7W ..... .75 | WL-218 ..... 14.00 | CK-501AX ..... 1.00 |
| 6SK7WA ..... 2.25 | CEP220 ..... 1.00 | RK-502 ..... 15.00 |
| 6SN7WGT ..... .90 | QK221 ..... 100.00 | 503/6246 ..... 100.00 |
| 6SU7GTY ..... 2.00 | 231D ..... 2.00 | CK522AX ..... 1.00 |
| 6V6GTY ..... .70 | RK-233A ..... .50 | 526AX ..... 1.25 |
| 6X4W ..... 1.00 | FG-235A ..... 30.00 | CK527 ..... 1.50 |
| 7AK7 ..... 4.00 | QK235A ..... 400.00 | WL-530 ..... 15.00 |
| 7BP7 ..... 1.00 | FG-238A ..... 50.00 | 531 ..... 6.50 |
| 7UP7 ..... 20.00 | QK-243 ..... 30.00 | 533AX ..... 1.00 |
| 7XP2 ..... 100.00 | WE-245A ..... 2.00 | 538AX ..... 1.75 |
| 7YP2 ..... 100.00 | QK-246 ..... 200.00 | 550 ..... .35 |
| 8DC15 ..... 7.50 | QK247 ..... 200.00 | CK-570AX ..... 2.00 |
| 8DS15 ..... 12.50 | QK-249 ..... 125.00 | 575A ..... 14.00 |
| 8RC12 ..... 125.00 | WE-249B ..... 4.00 | CUE576 ..... 20.00 |
| 12AT7WA ..... 2.25 | WE-249C ..... 2.75 | CUE578 ..... 7.00 |
| 12AU7WA ..... 2.00 | 250R ..... 4.50 | 578B ..... 7.50 |
| 12AY7 ..... 1.15 | WE-251A ..... 35.00 | 583 ..... 5.00 |
| 12DP7 ..... 10.00 | WE-252A ..... 6.50 | KU610 ..... 3.00 |
| 12GP7 ..... 12.00 | QK253 ..... 350.00 | HY-615 ..... .90 |
| 12SP7B ..... 25.00 | WE-254A ..... 2.00 | WL616 ..... 40.00 |
| 15E ..... Q | HK257B ..... 10.00 | BL619 ..... Q |
| 15R ..... 1.00 | FG-258A ..... 70.00 | KU627 ..... 6.00 |
| 16KB6 ..... 22.00 | WE-258B ..... 10.00 | KU628 ..... 7.50 |
| 16P ..... 1.00 | 259A ..... 3.50 | WL632B ..... 13.50 |
| 16RD6 ..... 22.00 | V-262 ..... 1200.00 | WL636 ..... Q |
| 16RP ..... 1.00 | FP265 ..... 15.00 | 642 ..... Q |
| 16RP-21 ..... 1.00 | WE269A ..... 6.00 | HK-654 ..... 10.00 |
| PJ22 ..... Q | FG-271/5551 ..... 35.00 | WL-658 ..... 80.00 |
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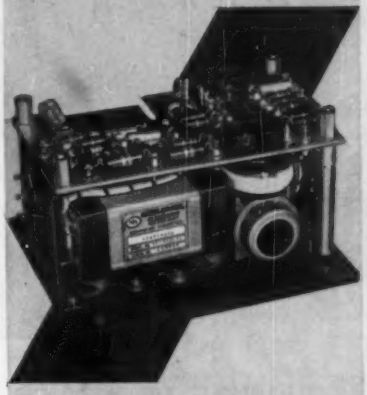

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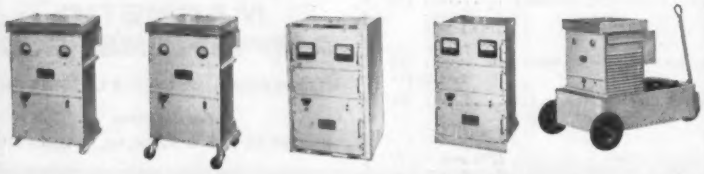



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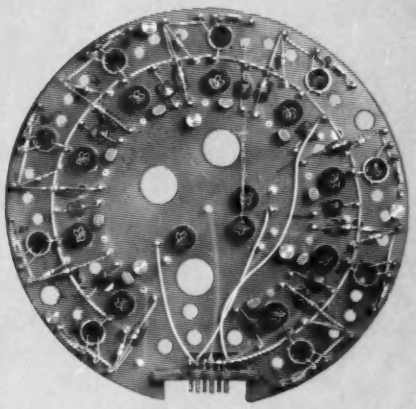

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7. Automated production-techniques eliminate contamination which would be caused by "handling", result in extraordinary electrical uniformity.
8. Stringent static and dynamic life tests give important assurances of quality.

RCA-6CG7 is *designer-preferred* because it has proven itself in the field. Now...because of further improvements brought to it by *RCA's Preferred Tube Types Program*...it is "better-than-ever!" Ask your RCA Field Representative for complete information on RCA-6CG7. For technical data on all tube types *preferred* by designers of TV, radio and phonograph sets, write RCA Commercial Engineering Section A-19-DE-3, Harrison, N. J.

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